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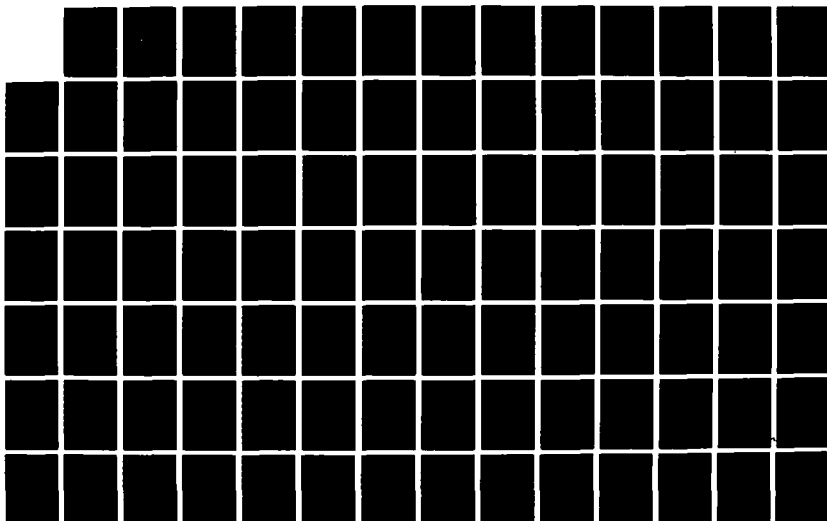
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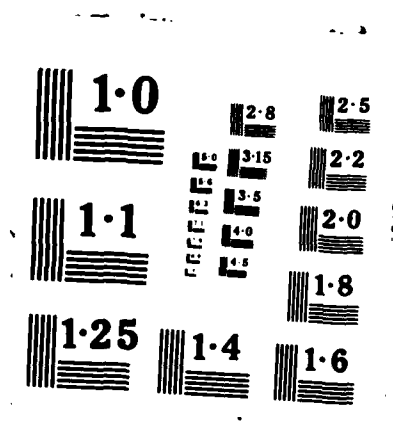
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U.S. Department
of Transportation

**Federal Aviation
Administration**

Office of Aviation Policy
and Plans

Washington, D.C. 20591

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Allocation of Federal Airport and Airway Costs for FY 1985

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December 19, 1986

Mr. Albert Blackburn
Associate Administrator for Policy and
International Development
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Dear Mr. Blackburn:

The allocation approach used in the enclosed Cost Allocation Study, prepared for the FAA under Contract DTSA01-85-C-00050, was jointly developed by Gellman Research Associates and Ernst & Whinney. This approach identified the relationships among FAA cost centers and users of the nation's airports and airways. Relationships were determined and quantified based on guidelines published by the Federal government Office of Management and Budget and the Cost Accounting Standards Board.

Very truly yours,

✓
Ernst & Whinney



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Section 1.0

INTRODUCTION

1.1 Purpose

The purpose of this study is to allocate current and future costs among users of the FAA's airport and airway system. These cost allocations provide information useful in analyzing user taxes to cover the period 1988 through 1997.

The present volume reports the results of the allocation of 1985 FAA costs among users. Estimates of future cost allocations are provided in Volume 2.

1.2 Overview of Methodology

FAA airport and airway costs are allocated to users using the concept of avoidable costs. These are the costs that would be avoided by the FAA if a user group discontinued its use of all or part of the FAA airport and airway system. Included in avoidable costs are both variable and other costs attributable to a user group's consumption of FAA services. Avoidable cost is the closest practical measure of long-run marginal costs that is available from FAA records.

There are two types of allocations made for the current system: a full cost allocation of the entire FAA budget, and an estimated minimum general aviation allocation. The main distinction between the two types of allocations is that in the latter case, general aviation users are not assigned a share of

joint costs. Otherwise, the methodologies employed for the two types of allocations are nearly identical, and are briefly explained below.

1.2.1 Full Cost Allocation

Under the full cost allocation, the entire FAA budget is assigned to 10 user groups and to the public interest. A six step procedure is employed:

Step 1--Separate the FAA budget into identifiable cost centers.

Step 2--Identify cost center resources expended in the public interest, defined as resources expended to produce public goods, redress externalities, or benefit non-aviators.

Step 3--Identify the use of each cost center by each user group.

Step 4--For each user group, evaluate the cost that would be avoided if it no longer utilized services produced by the cost center.

Step 5--For each cost center, identify joint costs, defined as those costs not avoidable by any single user group, but avoidable by all users together.

Step 6--Distribute joint costs among users.

The result of this six step procedure is that each user group is assigned two components of costs for each cost center--avoidable costs and a share of joint costs.

The 10 user groups identified in this study can be grouped into three general categories:

- o Airlines--domestic air carriers, international air carriers, freight air carriers, and commuter air carriers.
- o General aviation--air taxis, operators of general aviation piston aircraft, operators of general aviation turboprop and turbojet aircraft, and operators of rotorcraft.
- o Public sector--military and civil government users, and public interest expenditures.

This report documents costs allocated to each of the 10 user groups and to the public interest.

A summary of the 1985 full cost allocations to the three general user categories is shown in Table 1.1. The results in the table have been aggregated to include only the largest cost centers in the budget. The six general cost centers shown in the table are:

- o Operating site costs: labor, maintenance and leased communications costs at ARTCCs, FSSs, towers and TRACON.
- o F&E: capital expenditures made by the FAA to replace or improve facilities or equipment.
- o R&D: expenditures made by the FAA on research and development programs consistent with its mandate to build and maintain an efficient and safe airport and airways system.
- o Airport grants: grants made to operators of primary, commercial service, reliever and general aviation airports.

Table 1.1

SUMMARY OF RESULTS FOR 1985
MILLIONS OF DOLLARS

	Allocation Assuming Regulatory Costs Allocated to Users			Allocation Assuming Regulatory Costs Allocated to Public		
	Air Carrier	GA	Public Sector	Air Carrier	GA	Public Sector
Operating Sites	679.6	503.4	286.2	679.6	503.4	286.2
	46.26%	34.26%	19.48%	46.26%	34.26%	19.48%
			--			--
F&E	968.9	220.9	168.2	968.9	220.9	168.2
	71.35%	16.27%	12.39%	71.35%	16.27%	12.39%
			--			--
R&D	233.4	19.8	11.8	221.7	13.4	29.9
	88.08%	7.47%	4.45%	83.67%	5.07%	11.27%
			--			--
Airport Grants	606.2	305.1	13.4	606.2	305.1	13.4
	65.55%	33.00%	1.45%	65.55%	33.00%	1.45%
			--			--
Navaid Maintenance and Regulatory Costs	284.0	144.4	86.6	204.9	104.3	336.9
	55.15%	28.05%	16.81%	31.72%	16.14%	52.14%
			--			--
Overhead	360.0	204.2	137.4	268.5	155.6	148.6
	51.31%	29.10%	19.59%	46.89%	27.16%	25.95%
			--			--
Totals	3132.1	1397.8	703.6	2949.8	1302.7	983.2
	59.85%	26.71%	13.44%	56.34%	24.88%	18.78%
			--			--

Note: Numbers may not add due to rounding

- o NAVAID Maintenance and Regulatory Costs: costs incurred by the FAA in maintaining navigation and other equipment not located at operating sites and of regulating aircraft operations and manufacturing, and airports.
- o Overhead: Costs of headquarters and regional administration, and procurement.

Each cost category was evaluated to determine if some part of it was attributable to the public sector--e.g., military and civil government use of the airway system.

There are two sets of allocations in Table 1.1; the distinction between them pertains to the allocation of regulatory costs. There exist arguments for allocating these costs either to users or to the public sector. If the only beneficiaries of regulations are users of the aviation system, then these costs should be allocated to users. If the general public also benefits significantly, then the allocation should be attributed to the public sector. This issue is examined in detail in Volume 3.

The results for 1985 assuming regulatory costs are attributable to users are as follows: airlines as a group account for approximately 59.9 percent of all FAA costs; general aviation accounts for approximately 26.7 percent, while the government (including the military and public interest) accounts for the remaining 13.4 percent.

If regulatory costs are attributed to the public sector, then air carriers account for 56.3 percent, GA 24.9 percent and the public sector 18.8 percent.

The results in Table 1.1 also indicate that the percentage of costs attributable to particular user groups varies among cost centers. For example, general aviation piston operators are intensive users of ATC operations services and receive the benefits of a large share of airport grants, but are attributed a far lower share of the F&E and R&D budgets. Air carriers as a group are assigned a far lower share of the operations budget than their share of the F&E, R&D and grants budgets. The reasons for these distinctions are discussed in Section 2.0 of this report which presents the results for each cost center.

1.2.2 Minimum General Aviation Cost Allocation

The second set of results reported in this volume is a minimum general aviation allocation in 1985. This system represents the minimum costs that general aviation could incur consistent with current safety criteria. The word minimum also refers to the fact that no costs shared jointly by general aviation with other users are assigned to the minimum general aviation system. In other words, this allocation assumes other users would still require and pay for all facilities, services and projects which they share jointly with general aviation.

The methodology used to evaluate the minimum general aviation allocation is the same as that used for the full cost allocation in that they are both based on the concept of avoidable cost. However, two modifications to the basic method were required:

- o First, FAA establishment criteria were employed to identify the size and composition of the general

aviation air traffic system--those facilities and equipment which could be justified based solely upon activity by general aviation users.

- o Second, no costs jointly shared by general aviation with air carriers or government users were assigned to the minimum general aviation system.

The 1985 minimum general aviation allocation accounts for approximately 11.1 percent of that year's FAA budget if regulatory costs are allocated to users and approximately 10.6 percent if regulatory costs are allocated to the public. Either allocation would maintain existing safety standards for general aviation users. There are a number of issues concerning the interpretation of the minimum GA allocation which are addressed in Section 3.0.

1.3 References to Other Volumes

The databases which form the basis for the cost allocations reported in this volume are described in Volume 6. Future cost allocations and future minimum general aviation systems are discussed in Volume 2. The user tax options based on the results in Volumes 1 and 2 are reported in Volume 4.

Separate volumes have also been developed on public interest cost categories and on econometric cost estimation techniques. These are Volumes 3 and 5 respectively.

1.4 Organization of the Remainder of this Volume

Section 2.0 of this Volume reports the detailed results of the current full cost allocation study. First, an overview of

the allocation process and some of the conceptual issues involved in cost allocation are presented. This discussion is then followed by more specific discussions of each of the major cost centers in the FAA budget. Included in these discussions are the theory and concepts pertaining to the allocation of costs in each of these cost centers. The results for each cost center are also reported. Section 2.8 then provides a summary of the overall cost allocation at a more disaggregate level than that reported in Table 1.1.

Section 3.0 sets forth the minimum general aviation system allocation for FY1985. It describes the theories and methods employed, compares the minimum system allocation to the full-cost allocation, and notes the limitations of the minimum system as a basis for tax policies.

Appendix A provides a detailed discussion of the theory of joint cost allocation using Ramsey Pricing. Also reported are the results of the review of both theoretical and empirical work underlying the elasticities of demand utilized in the Ramsey Pricing analysis of joint costs.

Section 2.0

FULL COST ALLOCATION METHODOLOGY AND RESULTS

This section reviews the methodology and results of the full cost allocation of the FAA budget in 1985. The discussion is organized in the following manner. Section 2.1 reviews the theory and concepts applied to the problem in general. Included in this section is a brief discussion of Ramsey Pricing, a means for allocating joint costs to user groups. The subsequent sections of the report then review methodology and results for each of the major cost categories: public interest, operating sites, F&E, R&D, airport grants, and other operations items. The allocation of the entire budget is then reported in Section 2.8.

Much of the technical discussion, with regard to Ramsey Pricing, has been relegated to Appendix A. The reader also will find a separate discussion of a general aviation minimum cost allocation in Section 3.0.

2.1 Overview of Full Cost Allocation Methodology

The objective of the full cost allocation study is to attribute both variable and joint costs to users of FAA services; these allocations then serve as an input when considering alternative taxes in Volume 4. The full cost allocation also should meet two constraints:

- o It should be consistent with the promotion of efficient resource allocation.
- o Activities conducted in the public interest including the production of public goods, remedying externalities, or producing services for non-users of FAA services, should not be assigned to users, but instead to the public sector.

This section of the report reviews how this objective is satisfied subject to the two constraints. First, the nature of the production of FAA services is reviewed including the existence of joint costs. Following this is a discussion of the key cost concept utilized in this study--avoidable costs--and its application to the present problem. Finally, this section concludes with a review of the allocation of joint costs through the use of Ramsey Pricing.

2.1.1 Nature of FAA Production

The FAA is the single producer of organized and safe airspace in the United States. Most FAA activities support the provision of this general service. Like most large and complex organizations, however, the FAA produces multiple services which, together, result in organized and safe airspace. Since not all users equally partake of these services, it is important that the cost allocation problem be disaggregated to a level sufficient to capture the varying use of specific services.

For the present study, FAA activities have been subdivided into six major cost categories:

- o Operating Site Costs: these are the labor, maintenance, and leased telecommunications costs of

additional unit of service produced. Unfortunately, there are reasons why this ideal cannot be met in a full cost allocation of the FAA airport and airway system.

Several of the services produced by the FAA cannot be easily allocated among different user groups. In part, this is due to certain indivisibilities in the production of FAA services which take on some of the characteristics of public goods. For example, the results of an R&D program might be useful in improving navigation equipment in the field. But, the costs of R&D are invariant with use of navigation equipment. Furthermore, operating costs of field navigation do not vary with use. In such cases, there may be no obvious way to attribute costs to a specific user group, but it is equally clear that in the absence of all aviation, such R&D programs would not be necessary. These joint costs should be allocated to users, but an objective means must be found to determine how much to allocate to each user group.

The existence of indivisibilities in production and consumption is sufficient to warrant the application of Ramsey Pricing. This prescription simultaneously satisfies the revenue requirements including the coverage of joint costs while minimizing distortions in the market for FAA services.

What follows is a brief discussion of the application of Ramsey Pricing to the problem of FAA cost allocation. A more rigorous treatment can be found in Appendix A.

2.1.1.1 Ramsey Pricing--One way to think about the joint cost allocation problem is in terms of a market setting. When prices are set at long-run marginal costs, users consume only

operating Air Route Traffic Control Centers (ARTCCs), Flight Service Stations (FSSs), towers equipped with radar approach control services (TRACONS), and other towers. This cost category includes the direct costs of producing services which combine to form organized and safe airspace.

- o Facilities & Equipment (F&E): the capital expenditures made by the FAA to replace or improve operating sites, or other facilities which support them.
- o Research & Development (R&D): applied research programs designed either to improve the airport and airway system, or to improve flight safety.
- o Airport Grants: grants made under the Airport Improvement Program to primary, reliever, commercial service, and general aviation airports.
- o NAVAID Maintenance and Regulatory Costs: maintenance of navigation (and other) equipment and facilities, and the certification, inspection and regulatory programs included in the aviation standards and airports budget.
- o Overhead: costs of headquarters and regional administration and procurement.

These major cost categories correspond to appropriations in the FAA budget. Each was evaluated to determine if some part of it was attributable to the public sector.

In an ideal world, each user would be allocated the long-run marginal cost of the use of the airport and airway system--the additional long-run cost incurred by the FAA due to one

those services whose resource cost they are willing to pay for. When prices are established at levels above long-run marginal costs, then some users willing to pay the resource costs of production would be precluded from doing so. Ramsey Pricing minimizes the loss in net benefits due to setting prices above marginal costs. This is accomplished by varying the percentage markup above marginal costs inversely with demand elasticities.¹ If instead all markups were equal for all users, then those users exhibiting higher elasticities would decrease their demand for services disproportionately; as a result, net benefits to these users would be reduced substantially. Inelastic users are less sensitive to price changes and therefore are less likely to reduce their consumption of services. By charging higher prices to inelastic users, the change in net benefits is minimized. It can be shown that each identifiable user group exhibits an equal loss in net benefits per dollar of extra revenue collected.

In the present cost allocation study, Ramsey Pricing is utilized to develop markups above marginal costs sufficient to offset the joint costs identified in the FAA budget. In addition to identifying the cost of individual programs, only two other pieces of information are required to utilize the Ramsey prescription:

- o First, joint costs must be identified.
- o Second, relative elasticities among user groups must be established.

With regard to the latter, relative elasticities among all user groups are assumed to be equal except for the case of

general aviation-piston users. The elasticity of demand for this user group is assumed to be twice as high as that of other users. The rationale for this assumption is presented in detail in Appendix A. Here, it is only necessary to note that demand elasticity is made up of three components: substitution elasticity, income elasticity, and the ratio of purchases of a product to income. For reasons discussed below, these three components are likely to be higher (in absolute value) for GA-piston users than for other users. This will result in a larger price elasticity of demand. As a result, the markups above marginal costs for general-aviation piston operators will be lower than for other user groups.

2.1.2 Avoidable Costs

The discussion now turns to establishing the standards for measuring costs employed in the study. This is followed by the application of those standards to the FAA budget, the assignment of costs to users, and the treatment of joint costs.

Avoidable costs are used to identify attributable user costs throughout this study. Avoidable costs are defined as those costs which would disappear if a user group no longer consumed FAA services. Included in avoidable costs are both short-term variable costs and other non-variable costs attributable to a particular user's consumption of FAA services. Avoidable cost is the closest practical measure of long-run marginal cost that is available given the level and detail of information maintained by the FAA.²

In general, the avoidable cost concept is applied in two ways.

- o First, those cost categories which vary directly with output are evaluated through the use of econometric cost functions.

Such cost functions are developed for the four types of operating sites--ARTCCs, FSSs, TRACONS, and towers.

- o Second, other cost categories in the FAA budget are examined to determine whether they could be avoided if one or a limited number of user groups ceased to consume FAA services. Included are such categories as F&E, R&D, airport grants, and certain public sector categories.

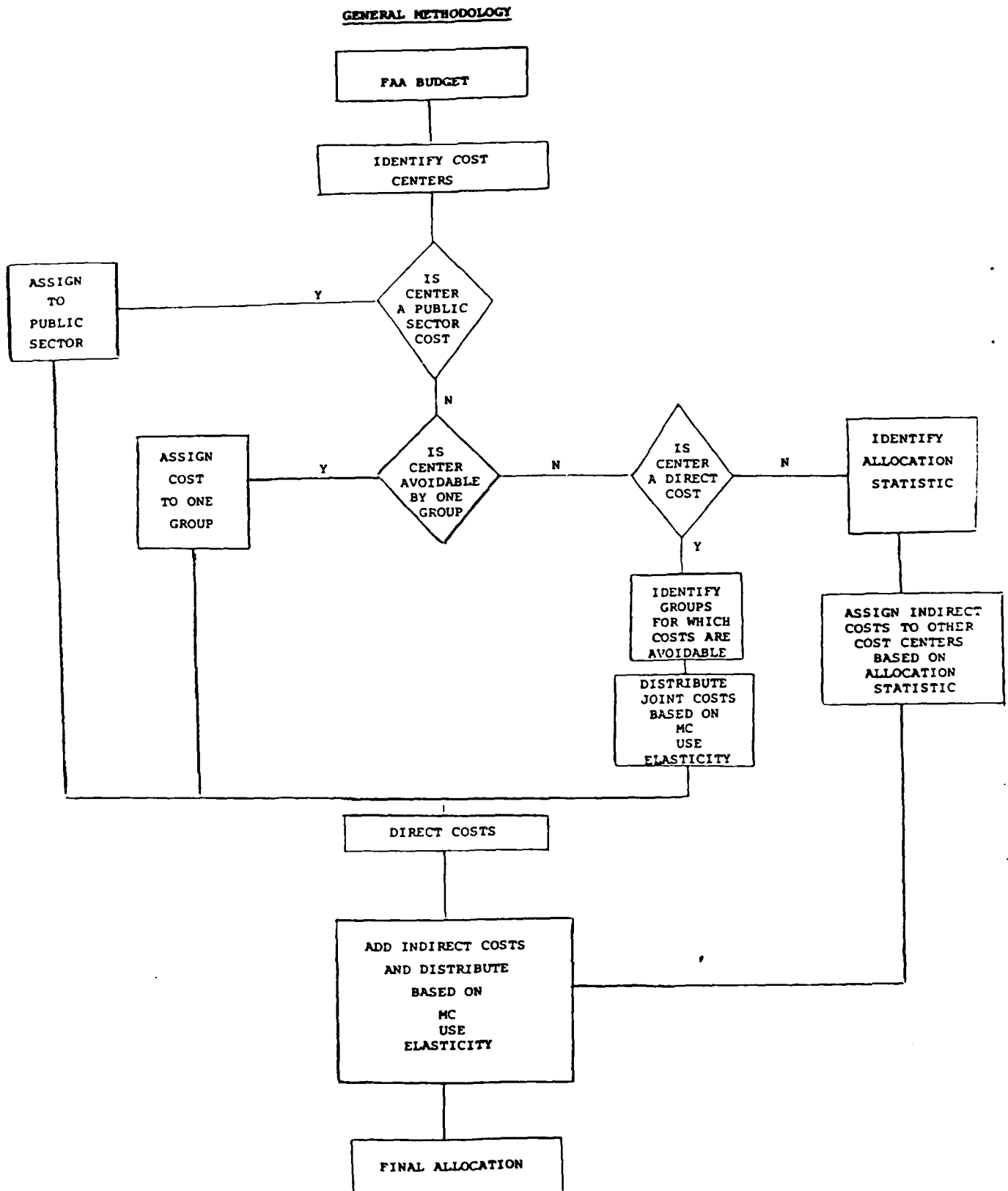
2.1.3 Identification of Avoidable Costs in Major Budget Categories

Figure 2.1.1 provides an overview of the cost allocation process.

The first step is to identify the cost centers in the FAA budget, and then to evaluate those items that should be allocated to the public sector. Included in this category are public goods, services to reduce externalities, and services provided to non-aviation users; the major components of this category are costs attributable to the military and civil government use of the air traffic control system.

All remaining costs are attributable to private sector users. Costs that would be avoided in the absence of a single user group are allocated to that group. Other costs in the FAA budget are jointly attributable to two or more user groups. Those joint costs directly related to the production of final FAA services--e.g., ARTCC handles, or airport grants--are assigned to

Figure 2.1.1



users based on airway activity, costs and relative demand elasticities. Indirect costs--e.g., headquarters administration --that support other direct and indirect activities are allocated to other cost centers using standard cost accounting techniques, and then to users of those cost centers in the same manner as other joint costs.

The following three sections describe in greater detail how costs are identified and allocated.

2.1.3.1 Assignment of Operating Site Costs to Users--In the case of FAA operating sites (ARTCCs, FSSs, towers, and TRACONs) econometric cost functions were estimated in order to identify the marginal cost of the use of these services by the following aggregate user groups:

- o Airlines, (Domestic, international and freight carriers),
- o Commuter airlines,
- o General aviation and other users including civil government and air taxi operators,
- o Military.

A number of alternative functional forms were tested for the cost functions. Linear functions of the following forms explained more of the variance in the data sets than others tested:

$$\text{Cost} = \text{Constant} + MC_i (\text{Activity Measure}_i)$$

This form says in words that the cost of operating an operating site such as an ARTCC depends on the amount of activity at the site, and on other resource costs which do not vary with activity, as explained by the constant term. The term MC_i is the

estimated long-run marginal (additional) cost to the FAA of one more service unit provided to user group i . For example, MC_i could be the additional cost to the FAA of providing radar separation to an airliner as it flies over an ARTCC service area. The costs are defined as labor, maintenance, and leased telecommunications. The marginal costs would therefore be the additional labor, maintenance and telecommunication costs of servicing an airliner at an ARTCC.

Costs are then assigned to more specific user groups based upon their estimated consumption of services produced at these facilities. The ten user groups of interest in this study are:

- o Airlines: domestic, international, freight and commuter airlines.
- o General Aviation: air taxis, general aviation piston operators, general aviation turboprop and turbojet operators, rotorcraft operators.
- o Public Sector: both military and civil government operators.

Finally, the constant terms in the cost functions are allocated among the ten user groups based upon the Ramsey Pricing concept described immediately above. As a result, the full cost of the labor, maintenance and leased telecommunications at FAA operating sites are assigned directly to the ten user groups.

2.1.3.2 Assignment of Other Costs to Users--Other cost centers including F&E, R&D and airport grants are treated similarly. While there are many details described below in the development of allocations for these major cost categories, there

is a single general method for applying the avoidable cost concept. Each line item in the budget for these major cost categories is evaluated to determine if some or all of it would be avoided if the following general user group categories no longer consumed the services produced in that cost category:

- o Air Carriers,
- o General Aviation (GA),
- o IFR Aviators (whether air carriers, GA, or government) flying under Instrument Flight Rules (IFR),
- o Public Interest.

When the line item could not be assigned to one of these categories, it was assigned to all users as a group. Applying the avoidable cost concept to the FAA budget in this manner results in the creation of an intermediate set of allocations. Shown in Figure 2.1.2 are the user groups included in each of these allocation categories.

Once these intermediate results were completed, it was necessary to allocate them to the ten user groups. Public sector costs were attributed directly to military or government users, or to the public interest in general. For example, the additional cost of providing service to the military at TRACONS and the cost of providing weather services for non-aviators were assigned directly to the public sector.

The remaining costs then were assigned to users based on Ramsey Pricing as a markup above marginal costs. For example, an F&E project undertaken specifically at ARTCCs for IFR users would be allocated among IFR users as a markup above ARTCC marginal costs. When the line item was not related directly to a

Figure 2.1.2

USER RESPONSIBILITIES FOR ALLOCATION CATEGORIES

<u>User Groups</u>	<u>Allocation Categories</u>				
	<u>Air Carriers</u>	<u>General Aviation</u>	<u>IFR Users</u>	<u>All Users</u>	<u>Public Interest</u>
Domestic Air Carriers (AC-D)	X		X	X	
International Air Carriers (AC-I)	X		X	X	
Freight Air Carriers (AC-F)	X		X	X	
Commuters (COM)	X		X	X	
Air Taxis (AT)		X	X	X	
GA-Piston (GA-P)		X	X	X	
GA-Turboprop & Turbojet (GA-T)		X	X	X	
Rotor		X		X	
Government Users		X	X	X	X
Military			X	X	X
Non-User Public Interest Activities					X

particular type of operating site, the allocation was based upon each user group's total use of the FAA airway system.³

2.1.3.3. Overhead--Finally, there were so-called indirect or overhead costs remaining in the budget which did not fit conveniently into any of the preceding categories. Headquarters administration is one example. A standard, multiple level cost allocation method was applied to these items. That is, the various departments within FAA supported by these overhead activities were identified. The overhead items were distributed among these departments based on the number of employees supported, or other statistics that reliably relate the overhead activity to a department it supports. Ultimately, the overhead items were distributed to final outputs of the FAA such as air traffic services, F&E, R&D and airport grants. Once assigned to these major cost categories, the overhead items were distributed to the ten user groups by applying the same methods previously described for other joint costs.

2.1.4 Summary

The preceding discussion provides only an overview of the cost allocation methodology. The specifics for each of the major cost categories are presented in the following sections. The discussion in the next section presents the methodologies employed in the assignment of costs to public sector categories.

2.2 FAA Costs Allocated to the Public Sector

Not all FAA costs should be borne by private sector users. The FAA can be thought of as a large "firm" which produces safe, organized airspace for the aviation community. In so doing, it

also provides services which benefit non-civilian aviation and non-aviators. Costs attributable to these services are allocated to the public interest, rather than to users, based on one of the following arguments:

- o Some services provided by the FAA are used by government agencies which provide public goods.
- o Some parts of the FAA system primarily benefit non-aviators.
- o Certain FAA programs redress externalities associated with the production and consumption of aviation services.

Volume 3 of this report describes in detail the allocation to the public interest of costs associated with the following activities:

- o FAA provision of ATCTs at low-activity airports,
- o Military use of FAA services,
- o Use by non-aviators of weather data collected by the FAA,
- o FAA regulatory activities related to safety, medicine, and the environment, and
- o Civil government use of FAA services.

In particular, the use of the FAA airport and airway system by the government, whether for military or non-military purposes, is an input to the production of public goods by the government. The provision of ATCTs at towers with so little activity that they fail to meet FAA cost-benefit criteria for ATCT establishment is an example of an FAA service which benefits

primarily non-aviators. Since these towers are not required for safety, yet Congress requires that they remain open, it can be inferred that their major reason for existence is to provide economic and social benefits to the members of the surrounding communities.⁴ A certain amount of the weather data collected by the FAA can also be seen as a benefit to non-aviators since it is essential to the construction of a picture of the nationwide weather patterns, from which forecasts used by many non-aviation groups (farmers, maritime operators, the general public, etc.) are produced.

One case of a public interest allocation, however, involves the costs incurred by the FAA in its programs to regulate the medical, safety, and environmental aspects of aviation. The production and consumption of FAA services generate certain external costs, such as air pollution. (This is just one example.) Whether these costs should be borne by users or by the public depends on whether the public has a right to clean air, or the aviation community has a right to pollute. If the former is true, users should bear the cost of reducing the impact of engine emissions, while if the latter is true, these costs should be borne by the general public.

There are also two possibilities for safety regulation. Since users are usually the only people directly affected by an aviation accident, it can be argued that they should pay for the costs of safety regulation. On the other hand, society may be viewed as having an interest in preventing catastrophic accidents. If such is the case, then the general public should bear the costs of safety regulation.

Because of the alternatives available with regard to the responsibility for regulatory costs, Volume 3 sets out two different public interest cost allocations. Both are summarized in Table 2.2.1. The first assumes that all regulatory costs dealing with medicine, safety and the environment are borne by users. The second allocation assumes that the general public should pay for these costs. A more detailed discussion of all of these issues is provided in Volume 3, along with details of the methodology used to estimate each cost category. The general methodology is outlined in Figure 2.2.1.

2.3 ATC Operating Costs

This section reports the allocation of operating site costs based upon cost functions developed for ARTCCs, FSSs, TRACONs and towers. These operating costs are part of the Operations and Maintenance budget of the FAA. The discussion begins with the theory and concepts of this approach followed by a more detailed discussion of the results for each of the four types of operating sites. Included are discussions of activity measures, cost measures and econometric results, and the allocation of joint costs.

2.3.1 Theory and Concepts

Operating sites as a group produce the major final product of the FAA--organized and safe airspace. Use of these sites varies in intensity among users. Therefore, it is important to disaggregate activity and costs to levels which reflect actual use of the airways system by each user group. The FAA maintains

Table 2.2.1

DIRECT COSTS INCURRED
BY THE PUBLIC SECTOR

FY1985

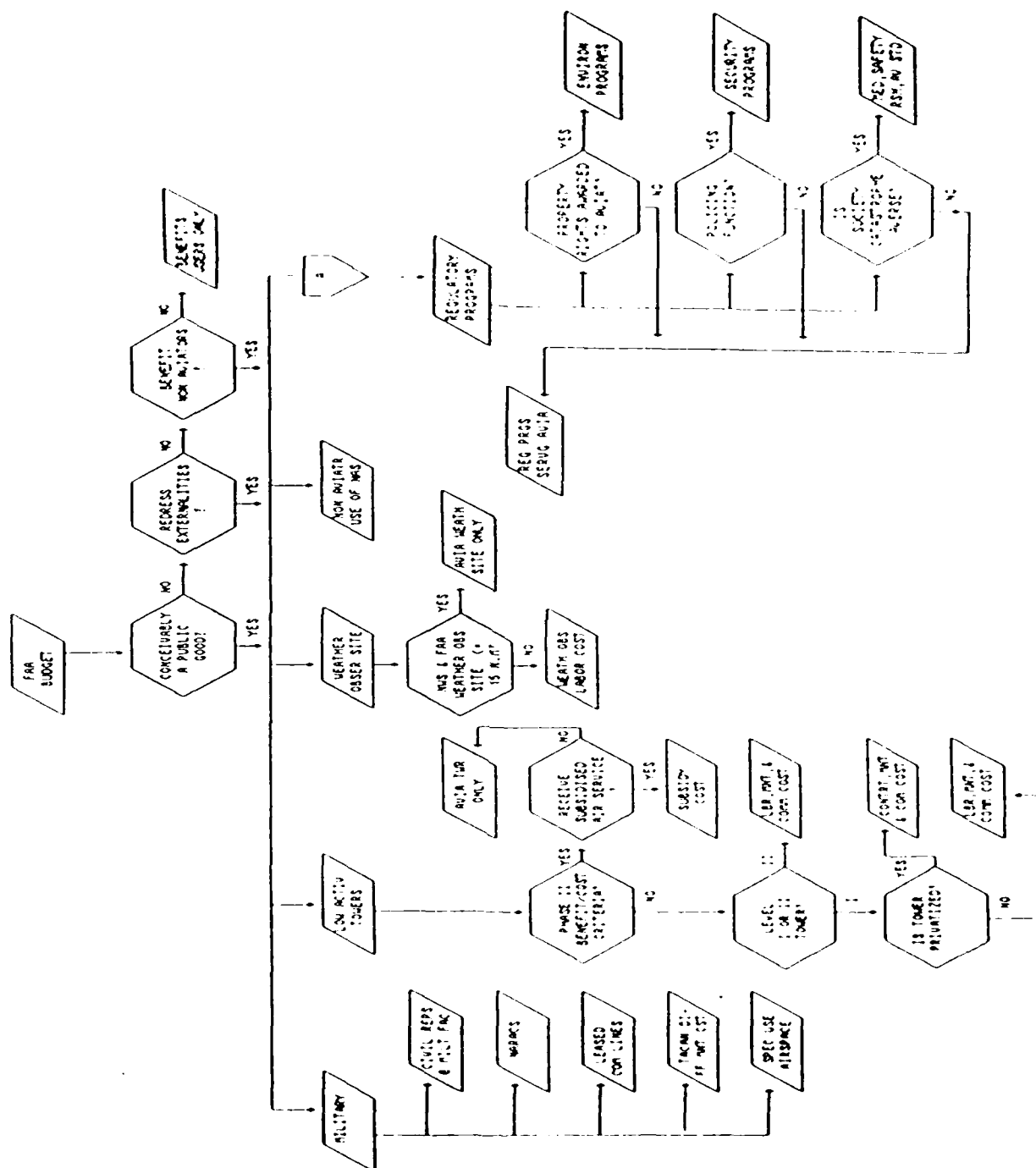
	<u>Direct Costs*</u>
ATCTs at Low Activity Airports	\$ 7,856,422
Military Use of FAA	\$ 511,083,522
FAA Weather Data Used by Non-Aviators	\$ 11,215,788
Regulatory Activities-- Safety, Medicine and Environment**	\$ 280,467,939
Non-Military, Government Use of FAA	\$ <u>23,947,132</u>
TOTAL	\$ 834,570,803

* Numbers may not add due to rounding.

** These costs allocated to users if they are deemed to
be the only beneficiaries of regulatory activities.

Figure 2.2.1

PUBLIC INTEREST METHODOLOGY



extensive data on the activity at these operating sites which, when combined with available cost data, were used to develop econometric cost functions for each type of operating site.

There are two chief advantages of this approach. First, econometric cost functions facilitate the direct observation of marginal costs, a subset of avoidable costs. Second, when independent variables are constructed so as to identify use of operating sites by individual user groups, it becomes possible to observe whether the marginal costs of serving user groups are different.

The general methodology used to estimate costs and to allocate them to users is shown in Figure 2.3.1. By combining cost and user group activity statistics, cost functions are developed for each of the four types of operating sites--ARTCCs, FSSs, TRACONs, and towers. The cost functions provide estimates of both marginal costs by user group and joint site costs.

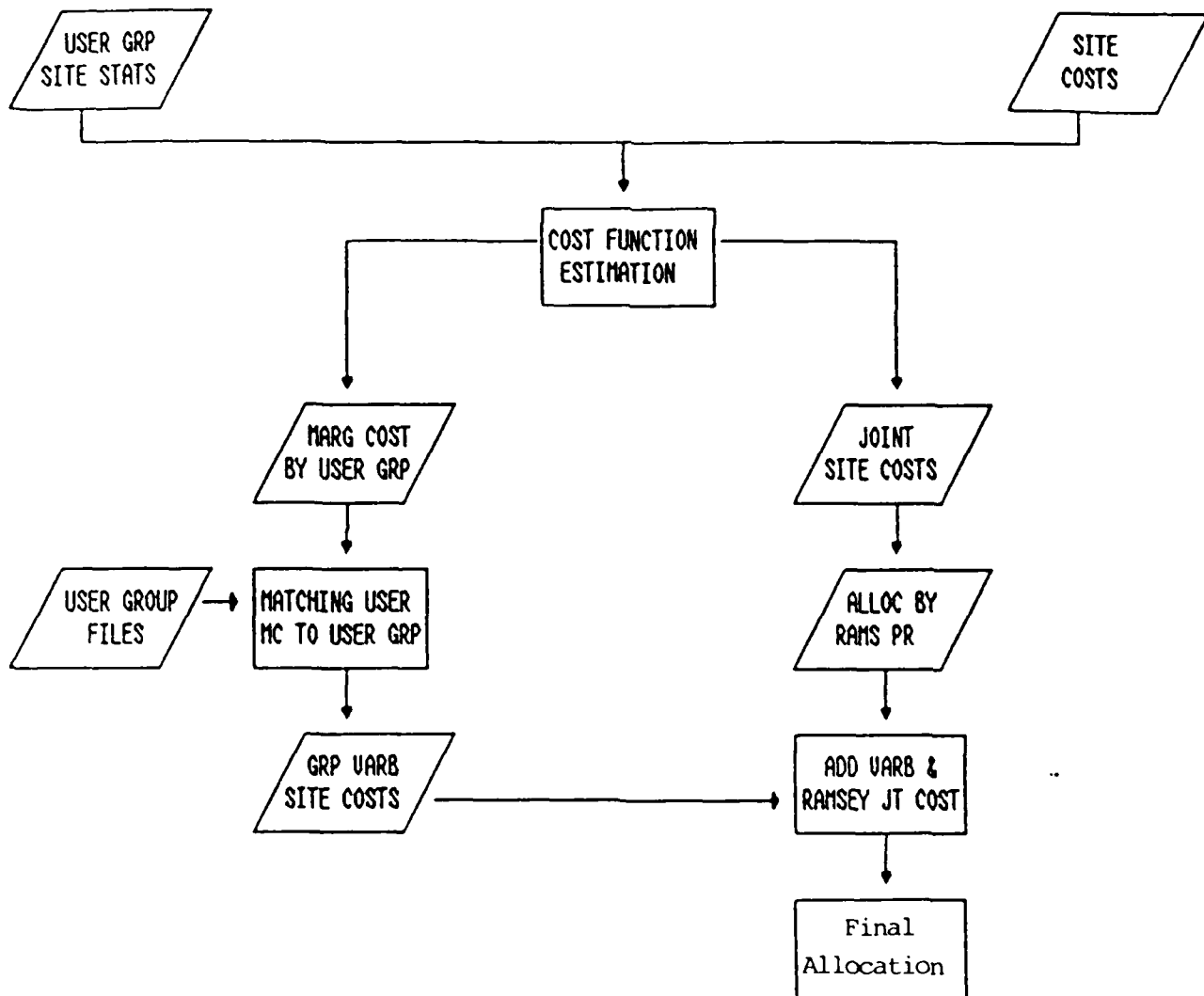
The marginal costs are then multiplied by activity measures to estimate total variable costs attributable to each user group. This is done by disaggregating activity statistics to the ten user groups of interest in this study. Joint costs are then allocated among the ten user groups based on activity, estimated marginal costs and relative demand elasticities.

There are two other issues which should be considered before reporting the results of each type of operating site:

- o The interpretation of the econometric results,
- o How the operating site results are used to allocate costs in other major cost categories.

Figure 2.3.1

ESTIMATION AND ALLOCATION
OF OPERATING SITE COSTS



2.3.1.1 Interpretation of Results--The cost functions

reported below do not provide complete estimates of long-run marginal costs. The costs included in those estimates are:

- o Labor costs including all labor overhead items as reported in the 1985 budget.
- o Maintenance labor including labor maintenance overhead as reported in the budget.
- o Leased telecommunications costs as estimated from the FAACIS database.

In addition to the above, the following would also be needed to be incorporated into the cost functions in order to provide complete estimates of long-run marginal costs:

- o Depreciation,
- o The cost of capital,
- o The cost of non-labor inputs used to maintain capital equipment at the operating sites.

Information was unavailable on these variables to include them in the econometric analysis. There exists no dependable information on the consumption and durability of capital at individual FAA sites. Nor is there any feasible way to identify non-labor maintenance expenditures at the site level. Without these two items, there is no way to evaluate the cost of capital in the cost functions since an adequate measure of capital cannot be constructed.

It should be noted that these are items that have been treated in this study in another way, however. Capital expenditures have been allocated among users based on the FAA's F&E budget. These results are reported in Section 2.4. Non-

labor maintenance resource expenditures are included in the navaid maintenance account which is discussed in Section 2.7.

2.3.1.2 Use of Operating Site Results to Allocate Costs

in Other Major Cost Categories--The other major cost categories identified in this study provide products and services utilized by the operating sites to produce the FAA's major final output--organized and safe airspace. For example, new capital is identified in the F&E budget. The costs of these other major categories could not be incorporated into the econometric analysis of the operating sites, but, in many cases, can be attributed to a particular type of operating site. For example, many F&E projects pertain only to the IFR operations guided by ARTCCs. It is appropriate that these costs be allocated among users of ARTCCs. In order to facilitate this allocation, F&E costs attributable to IFR users are allocated as a markup above ARTCC marginal costs. As a result, these allocations depend upon:

- o Use of ARTCCs by individual user groups,
- o The elasticity of demand evidenced by those user groups,
- o The estimated marginal cost of their use,
- o The size of the cost to be allocated.

In other cases, there is no direct relationship between the operating sites and a line item from a major cost category. For example, many F&E projects cut across all operating sites and cannot be easily allocated to only a single type. Under these circumstances, the same methods are used, but costs are allocated to users based upon their aggregate use of all FAA operating

sites.⁵ Each user group's marginal costs are defined as the expected cost at all FAA operating site per operation.

The allocation of these costs to users is based on the following:

- o The elasticity of demand evidenced by each user group,
- o Each user group's activity at FAA terminal sites,
- o The marginal costs of those operations at all FAA operating sites,
- o The size of the joint costs to be allocated.

2.3.2 Econometric Results

Table 2.3.2.1 summarizes the FY1984 estimates of marginal costs for ARTCC's, FSSs, TRACONs and towers. For each type of facility, the table shows the output measure, joint site costs, marginal costs by user group category and adjusted R-squared. This year was chosen because it was the latest time period for which all relevant cost and operations data were available. The results should be applicable to 1985 because FAA wages and salaries scales which make up 95 percent of the costs included in the equation, were the same in both years.

The results reflect how the FAA allocates its costs among operating sites. Except for FSS services, the marginal costs of military and air carrier operations are higher than similar services provided to general aviation users. At ARTCC's, military costs are higher than air carrier costs, while the reverse is true at towers. These results are due in part to the following factors:

- o FAA establishment criteria determine whether and how much equipment will be located at each site.

Table 2.3.2.1

ECONOMETRIC RESULTS FOR FAA OPERATING SITES

1984

Current Dollars

Long-Run Marginal Costs

Type of Site	Output Measure	Joint Costs Per Site	Air Carrier	Commuter	General Aviation	Military	Adjusted R-Squared
ARTCC	Handles	\$4,082,285	\$13.93	\$13.93	\$12.63	\$21.30	.896
FSS	Pilot Briefs	\$89,919	\$6.86	\$6.86	\$6.86	\$6.86	.929
	IFR Flight Plans	--	\$6.86	\$6.86	\$6.86	\$6.86	--
	VFR Flight Plans	--	\$13.68	\$13.68	\$13.68	\$13.68	--
	Air Contacts	--	\$3.87	\$3.87	\$3.87	\$3.87	--
TRACON	Operations, Seconds & Overs	\$850,312	\$12.80	\$12.80	\$3.44	\$12.80	.867
TOWER	Operations	\$386,623*	\$7.91	\$1.86	\$1.44	\$4.45	.555

* Joint Tower costs are \$85,133 lower at Level 1 facilities.

Establishment criteria benefits and costs are different for each user group, and are reflected in the maintenance costs at the different sites.

- o FAA staffing standards, which determine the number of ATC personnel at each site, also weigh operations by user groups differently.
- o At ARTCCs, higher military costs are due to the additional resources required to handle special use airspace.

Statistical tests showed that the marginal cost of producing FSS services did not vary across user groups.

The results shown in the table are long-run marginal costs because they trace out the costs at different sized facilities. Tests for non-linearities proved to be insignificant indicating that FAA long-run marginal costs are constant for different sized facilities.

Finally, it should be noted that FAA activity statistics were modified to separately identify commuter operators. This was necessary because FAA activity counts for both air carriers and air taxis include commuter operations. OAG statistics were used to identify separately commuter and airline operations; the residual FAA statistics were then assumed to be attributable air taxi operations.

FAA general aviation activity counts were split among air taxi,⁶ piston, turbo, rotor and government users based upon two surveys conducted by FAA:

- o "General Aviation Activity and Avionics Survey."
- o "General Aviation Pilot and Aircraft Survey."

Together, the two surveys provided sufficient information from which estimates of activity at FAA facilities could be developed.

What follows is a discussion of the allocations for each of the four types of operating sites.

2.3.3 ARTCCs

The main output of the FAA's 22 Air Route Traffic Control Centers is separation of aircraft in controlled airspace between terminal areas. This output is measured by handles, which is defined as two times ARTCC departures plus overs. Under this definition of output, an ARTCC separates IFR aircraft which depart and land in its area, and which fly over its area.

The econometric results reported in Table 2.3.2.1 are comparable to estimates of marginal costs reported in the 1978 Cost Allocation Study.⁷ The earlier results originally estimated in 1976, but expressed in 1984 dollars⁸ per handle are as follows:

Air Carriers	\$22.27
General Aviation	\$16.03
Military	\$28.34

The real dollar marginal cost of producing handles at ARTCC's has declined substantially since 1976. The costs in the earlier period were between 26 and 60 percent higher.

2.3.3.1 Final Allocations--Shown in Table 2.3.3.1 are the final allocations of variable and joint ARTCC operating site costs to the ten user groups. Variable costs in this table are defined as the product of the estimated marginal costs multiplied by estimated activity by each group. Joint costs were allocated to users based on activity, marginal costs and relative demand

Table 2.3.3.1

ALLOCATION OF 1985 ARTCC O&M COSTS (CURRENT DOLLARS)

ARTCC USERS	YEAR= 08-Jul-86	1985		ARTCC		ARTCC DIRECT	
		ESTIMATED HANDLE	ESTIMATED MC	ARTCC VARIABLE COSTS	JOINT COSTS ALLOCATED BASED ON RAMSEY PRICING	COSTS USING RAMSEY PRICING TO ALLOCATE JOINT COSTS	
AIR CARRIER-DOMESTIC		13,810,128	\$13.93	\$192,416,508	\$37,184,240	\$229,520,747	
AIR CARRIER-INTL		753,332	\$13.93	\$10,496,179	\$2,024,009	\$12,520,188	
AIR CARRIER-FREIGHT		945,700	\$13.93	\$13,176,433	\$2,540,850	\$15,717,284	
COMPUTER		2,731,273	\$13.93	\$38,054,823	\$7,338,223	\$45,393,047	
AIR TAXI		929,534	\$12.63	\$11,741,878	\$2,264,221	\$14,006,099	
GENL AVIATION-PISTON		2,556,486	\$12.63	\$32,293,525	\$2,839,822	\$35,133,347	
GENL AVIATION-TURBO		5,765,725	\$12.63	\$72,832,639	\$14,044,531	\$86,877,170	
ROTOR		0	\$12.63	\$0	\$0	\$0	
GOVERNMENT		204,875	\$12.63	\$2,587,983	\$499,048	\$3,087,032	
MILITARY		4,873,478	\$21.30	\$103,805,067	\$20,017,040	\$123,822,126	
		<u>32,570,531</u>		<u>\$477,405,056</u>	<u>\$88,671,985</u>	<u>\$566,077,041</u>	

elasticities. The table also reports the total operating site costs allocated to each user group.

Domestic air carriers and the military share the largest shares of ARTCC costs accounting for approximately 41 and 22 percent of total direct costs respectively. The only other group with a share larger than 10 percent is operators of GA turboprop and turbine aircraft who account for 15 percent of the costs.

2.3.4 FSSs

FSSs produce multiple outputs; the ones which consume most FSS resources and costs are: IFR flight plans, VFR flight plans, pilot briefs and air contacts. Most of these services are provided to general aviation users, although some use is reported for military and air carrier users.

In 1984, there were 306 FSSs operated by the FAA. At each of these sites, the FAA maintains counts of the four types of services. Preliminary analysis of this data indicated that there were no differences in the costs of providing FSS services for different users. Therefore, the activity measures employed in the econometric cost analysis were: total IFR flight plans, VFR flight plans, pilot briefs and air contacts produced by each FSS in 1984.

The econometric results reported in Table 2.3.2.1 are similar to those reported in the recently completed "Flight Service Station Privatization Evaluation Report."⁹ The results for 1984 from that study were:

- o Pilot Briefings \$7.24
- o IFR Flight Plans \$7.24

- o VFR Flight Plans \$8.12
- o Aircraft Contacts \$5.67

Both studies report the same numerical order of marginal costs with air contacts being the least expensive service and VFR flight plans being the most. These results are consistent with the time-and-motion studies reported in the FSS privatization report.

The reported air contact and VFR flight plan cost estimates are somewhat different for the two studies. While both used the same data for ATC labor expenditures at FSSs, they employed different data on maintenance and leased telecommunications costs. It is these distinctions which probably result in the differences in marginal costs. It is believed that the present study reports more accurate estimates since it was possible to gather more detailed data on leased telecommunications and maintenance expenditures.

The econometric results from the 1977 study are quite different from those of either the present study or the recent FSS privatization study. The earlier results originally estimated in 1972 but expressed in 1984 dollars are as follows:

Pilot Briefs	\$2.43
Flight Plans	\$1.80
Air Contacts	\$2.77

Even after adjusting for inflation, the earlier period estimates are substantially lower, ranging between 13 and 82 percent of 1984 costs. One reason for the large discrepancy may be that the earlier work for FSSs is based on results from the 1973 Cost Allocation Study. The effects of increased demand, capital

obsolescence, and changes in relative factor prices are not well represented in these earlier results.

2.3.4.2 Final Allocation of FSS Operating Site Cost to

Users--The results of the allocations to users are shown in Table 2.3.4.1. The estimation of variable costs attributable to each user group was a two-step procedure:

- o For each of the four services produced by FSSs, marginal costs were multiplied by the quantity of service consumed by each user group to yield an estimated variable cost for each user of each of the four services.
- o These variable costs were then added together to yield an estimate of total variable costs attributable to each user group.

FSS joint costs were then allocated among users based upon activity, marginal costs and relative demand elasticities.

GA piston operators account for over 57 percent of the direct costs of operating FSSs. Military and GA turboprop and turbine operators are the next largest user groups, accounting for 11 and 8.5 percent respectively. Air carriers as a group account for less than 11 percent of the total.

2.3.5 TRACONS

TRACONS produce three identifiable services:

- o Radar approach control services at the principal airport,
- o Approach control services at secondary airports guided by the TRACON radar,

Table 2.3.4.1

ALLOCATION OF FSS O&M COSTS BASED ON RAMSEY PRICING

FSSAFUT1		08-Jul-86				
USERS	1985		FSS MCI (FUTURMC)	TOTAL VAR. COSTS FOR FSS'S	FSS JOINT COSTS ALLOCATED BASED ON RAMSEY PRICIN	FSS DIRECT COSTS USING RAMSEY PRICING TO ALLOCATE JOINT COSTS
	FSS Services					
AIR CARRIER-DOMESTIC	1,365,787	\$6.47	\$8,833,546	\$1,663,425	\$10,496,951	
AIR CARRIER-INTL	60,416	\$6.47	\$390,758	\$73,562	\$464,340	
AIR CARRIER-FREIGHT	106,191	\$6.47	\$686,815	\$129,331	\$816,146	
COMMUTER	1,852,310	\$6.47	\$11,980,251	\$2,255,947	\$14,236,198	
AIR TAXI	1,900,041	\$6.47	\$12,208,961	\$2,314,079	\$14,683,040	
GENL AVIATION-PISTON	19,589,431	\$6.47	\$126,699,257	\$10,902,575	\$137,601,832	
GENL AVIATION-TURBO	2,659,825	\$6.47	\$17,203,042	\$3,239,427	\$20,442,470	
ROTOR	1,365,551	\$6.47	\$8,832,023	\$1,663,116	\$10,495,141	
GOVERNMENT	405,689	\$6.47	\$2,623,891	\$494,093	\$3,117,985	
MILITARY	3,546,941	\$6.47	\$22,940,676	\$4,319,855	\$27,260,532	
TOTAL	22,852,182		\$212,479,220	\$27,055,414	\$239,534,634	

- o Radar service for flights made over the terminal area controlled by the TRACON.

While the FAA maintains data on the consumption of these three services by air carriers, air taxis, general aviation and the military, preliminary statistical evaluations indicated that there were no differences in the costs of providing the services. Therefore, the sum of operations, seconds and overs is used as the activity variable in the TRACON analysis.

The econometric results are not directly comparable to those reported in the 1977 study. The earlier study reported an analysis of both towers and TRACONs. Furthermore, activity at TRACONs was measured as operations; this measure ignores the radar services (measured by seconds and overs) provided to other aircraft operating in or flying over the terminal area.

2.3.5.1 Final Allocations--Table 2.3.5.1 reports the final allocations of TRACON costs to the ten user groups. Included in this table are both the variable and joint operating cost allocations. The latter were allocated among users based on activity, marginal costs and relative demand elasticities.

Domestic airlines and commuters together account for over 50 percent of direct TRACON costs (38 and 20 percent respectively). Military and general aviation piston operators also account for sizeable shares of 16 and 15 percent of costs.

2.3.6 Towers

FAA towers produce landing and take-off clearance services in the terminal area. Service is measured by counts of operations at each tower. These counts are disaggregated into the four FAA user

Table 2.3.5.1

ALLOCATION OF TRACON O&M COSTS BASED ON RAMSEY PRICING

TRAFUT1	08-Jul-66	YEAR=	1985	TRACON		TRACON DIRECT COSTS USING RAMSEY PRICING TO ALLOCATE JOINT COSTS
				1985	1985	
USERS		ESTIMATED OPS+SEC+ OVERS	ESTIMATED MC	TRACON VARIABLE COSTS	JOINT COSTS ALLOCATED BASED ON RAMSEY PRICING	
AIR CARRIER-DOMESTIC		10,442,145	\$12.80	\$133,659,461	\$67,968,631	\$281,628,092
AIR CARRIER-INTL		454,385	\$12.80	\$5,816,127	\$2,957,622	\$8,773,749
AIR CARRIER-FREIGHT		803,155	\$12.80	\$10,280,382	\$5,227,789	\$15,508,171
COMPUTER		5,434,131	\$12.80	\$69,556,874	\$35,371,125	\$104,927,999
AIR TAXI		1,998,968	\$3.44	\$6,876,452	\$3,496,819	\$10,373,271
GENL AVIATION-PISTON		19,288,750	\$3.44	\$66,050,580	\$13,389,604	\$79,440,183
GENL AVIATION-TURBO		2,461,534	\$3.44	\$8,467,676	\$4,305,990	\$12,773,667
ROTOR		1,378,768	\$3.44	\$4,742,963	\$2,411,896	\$7,154,859
GOVERNMENT		400,533	\$3.44	\$1,377,833	\$700,657	\$2,078,490
MILITARY		4,382,317	\$12.80	\$55,069,663	\$28,004,076	\$83,073,739
		46,876,687		\$351,896,010	\$163,834,209	\$525,732,219

group categories: air carrier, commuter, general aviation and military operations.

As was the case with TRACONS, the results of the present study cannot be directly compared with those of the 1977 study. The earlier study considered TRACONS and towers together, and used a different measure of activity at TRACONS.

2.3.6.3 Final Allocations to Users--Shown in Table 2.3.6.1 are the final allocations of tower costs to users. Included in the table are the allocations of variable and joint cost components. The latter allocations were based upon activity, marginal costs and relative demand elasticities.

General aviation piston operators account for approximately 37 percent of direct tower costs. The remaining costs are fairly evenly distributed among the military (14.6 percent), GA turboprop and turbine operators (12.5 percent), commuters (nine percent), air taxis (eight percent) and rotor operators (seven percent).

2.4 Facilities and Equipment

This section reviews the methodology employed to allocate FAA facilities and equipment (F&E) costs among user groups. The discussion first explores the theory and concepts involved in the allocation procedures, and alternatives for considering amortizing the cost of F&E over its useful life. Also discussed are the measures of F&E employed in the study. Thereafter, the allocations are presented.

ALLOCATION OF TOWER O&M COSTS BASED ON RAMSEY PRICING

43

2.4.1 Theory and Concepts

The treatment of F&E in the context of the FAA Cost Allocation Study raises two major questions:

- o Should F&E expenditures be amortized?
- o How should the costs of projects be allocated among users?

Each of these is discussed in turn below.

2.4.1.1 Should F&E be Amortized?

The F&E budget includes virtually all of the capital expenditures made in the airway system. Because capital assets are durable, they provide services for more than one year. Expenditures made on an F&E project in the current year will provide benefits in future years as well. The costs of those future capital services normally are recognized in the year they are consumed, instead of in the year the capital expenditure is made. In the parlance of accounting, capital service costs are "amortized" over the life of the asset.

Traditionally, the FAA has not amortized its capital expenditures. This was true for the base year (1985) reported in this volume. Therefore, for 1985, all capital expenditures in the F&E budget are recognized in 1985; in the parlance of accounting, all F&E costs were expensed for 1985.

In Volume 2, there is an extensive review of why F&E costs should be amortized in future years. The results for the future reported in that volume are based on an amortization schedule developed for this study.

2.4.1.2 How Should F&E be Allocated Among Users--The FAA

publishes information on current and future F&E projects in its

annual congressional budgets. These project descriptions provide information on the purpose of each F&E project, and how it will be used in the airway system. Each of these project descriptions was examined to determine if projects could be avoided in the absence of activity by specific user groups. This is akin to the avoidable cost concept used throughout the study, and is similar to the method used to identify the attributable cost of R&D projects and airport grants. The methodology is outlined in Figure 2.4.1.

After a review of the project summaries, it was determined that avoidable costs could be identified for the following user group categories:

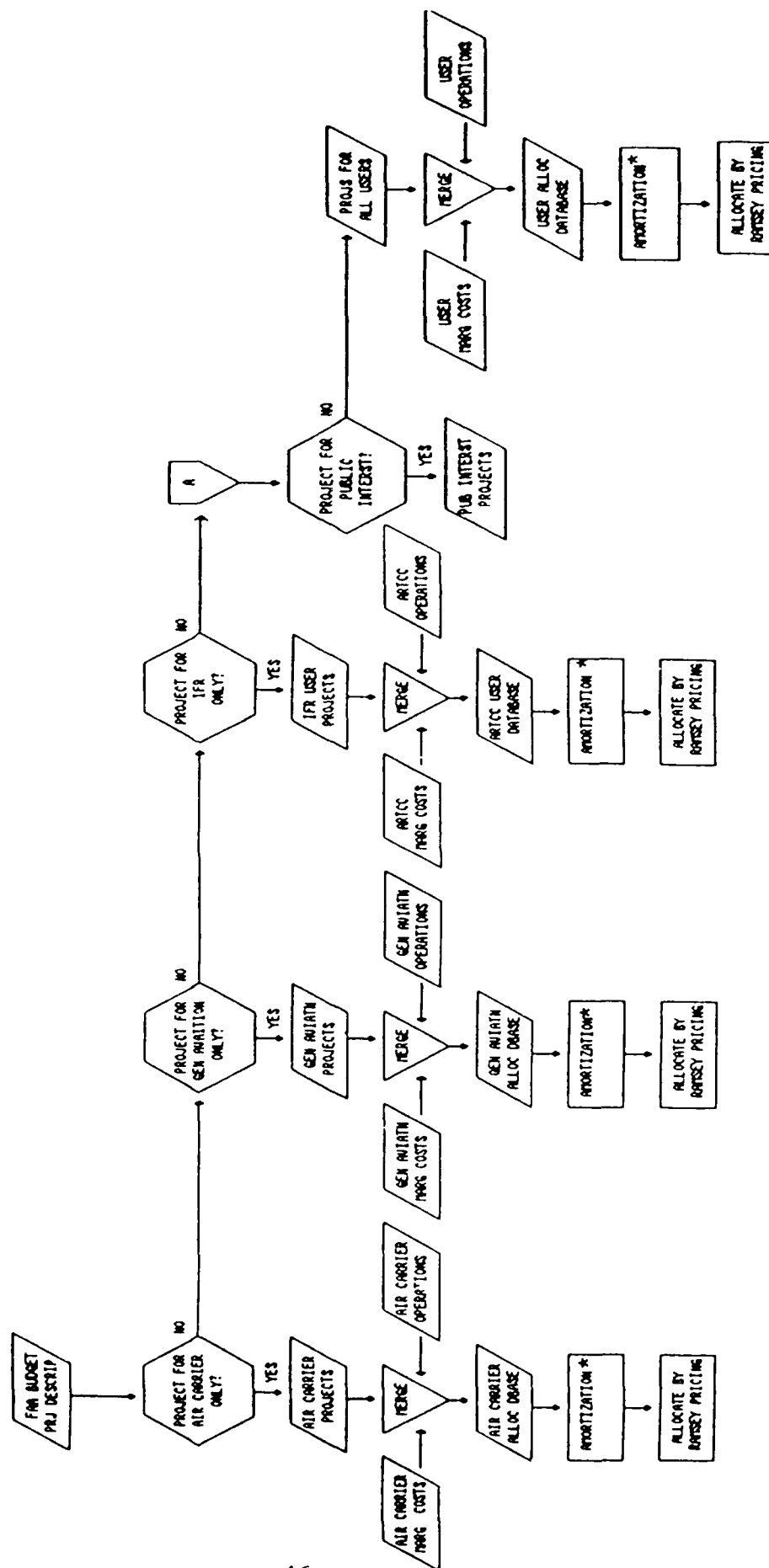
- o Air carriers,
- o General aviation,
- o IFR users,
- o Public interest,
- o All users.

The last category represents those F&E projects consumed by all users jointly.

The F&E budgets for the years 1984 through 1992 were separated into the above five cost categories. The average allocation among the five groups over the period 1984 through 1992 was then used to allocate F&E for 1985. This average allocation was deemed to be more representative than a single year's allocation which could provide a distorted view of the long-term cost responsibility of different user groups.

Figure 2.4.1

AMORTIZATION AND ALLOCATION
OF F&E R,F,&D PROJECTS



* Amortized in future years only.

The five F&E cost categories were disaggregated to the ten user group level based on activity at ATC sites, marginal costs at those sites, and relative demand elasticities. With the exception of the IFR user category, the joint cost allocations were based upon each group's use of all airway facilities. The IFR cost category was allocated based upon activity at ARTCCs only.

2.4.2 F&E Allocations

Table 2.4.1 shows the allocation of 1985 F&E among the ten user groups. Domestic air carriers account for 50 percent of F&E costs. This result follows directly from the finding that 73 percent of all F&E money was spent on either air carrier projects, or projects benefitting IFR users--two categories dominated by domestic air carriers. Commuters and the military account for the next largest shares (16 and 11 percent respectively). Operators of GA turboprop and turbine aircraft account for almost nine percent of these costs.

2.5 Research and Development

This section discusses how research and development (R&D) costs were assigned to user groups. Research and development funded by FAA generally refers to applied research which is undertaken either to improve the performance of the air traffic control and airport system or to improve flight safety. The following sections describe the theory and concepts used to allocate R&D costs, the data used to measure these costs and the allocation of joint R&D costs.

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Table 2.4.1

FINAL ALLOCATION OF F&E DIRECT COSTS TO USERS
1985 FISCAL YEAR

13-Aug-86

USERS	GA PROJECTS	PROJECTS FOR ALL USERS	(*) IFR PROJECTS	AIR CARRIER PROJECTS	TOTALS
AIR CARRIER-DOMESTIC	\$0	\$100,300,052	\$168,920,534	\$394,161,895	\$671,383,280
AIR CARRIER-INTL	\$0	\$5,414,181	\$9,214,491	\$19,784,960	\$34,333,633
AIR CARRIER-FREIGHT	\$0	\$7,829,419	\$11,567,459	\$28,495,239	\$47,892,118
COMMUTER	\$0	\$39,198,781	\$33,407,950	\$142,664,386	\$215,271,037
AIR TAXI	\$6,714,089	\$10,626,765	\$10,300,078	\$0	\$27,640,932
GENL AVIATION-PISTON	\$23,157,518	\$34,783,114	\$9,851,024	\$0	\$67,791,656
GENL AVIATION-TURBO	\$20,666,975	\$32,710,780	\$63,939,048	\$0	\$117,316,803
ROTORCRAFT	\$3,146,213	\$4,979,687	\$0	\$0	\$8,125,900
GOVERNMENT	\$1,450,005	\$2,295,004	\$2,271,965	\$0	\$6,016,973
MILITARY	\$0	\$59,683,017	\$91,129,451	\$0	\$150,812,469
TOTAL TO USERS	\$55,134,000	\$305,821,600	\$400,610,000	\$585,026,400	\$1,346,592,000
OTHER PUBLIC SECTOR (NARACS)					\$11,407,200
TOTAL F&E					\$1,358,000,000

(*) Allocation based on ARTCC marginal costs and activity.

2.5.1 Theory and Concepts

Research and development is an input into the production of current and future FAA services. It consists of projects undertaken to improve the state-of-the-art in FAA operations and aircraft safety. In this respect, it is similar to facilities and equipment (F&E) expenditures (discussed above). However, R&D costs are not amortized because the economic life of the output of each project is not known. For example, research into the crashworthiness of aircraft may lead to results that are implemented in FAA aircraft design regulations. However, when a project is undertaken, it is not known if the results will be implemented; nor is it known over what time period they will be useful.

It is proper to expense R&D costs because a consistent basis does not exist for amortization. This approach conforms with generally accepted accounting principles (GAAP)¹⁰ and normal business practice. While many R&D projects appear to be related to actual hardware development programs conducted by FAA, these specific budget items relate to the more forward-looking activities conducted by FAA. Thus, many R&D programs eventually lead to the development of hardware and other information used by FAA. Once the results are implemented any future expenditures would be categorized under F&E.

A flow chart which shows how these costs are allocated was presented above in the discussion of F&E costs (Figure 2.4.1). These projects generally are applied and the user groups which would benefit can often be specifically identified. Under the avoidable cost concept used throughout this study, the costs of

an R&D project are assigned to a user group if the project would not be undertaken if that group did not exist. In particular, each project passes through a series of decision rules:

- o Does the project benefit air carriers only?
- o Does the project benefit general aviation only?
- o Does the project benefit IFR users only?
- o Does the project satisfy the public interest criteria?

Or,

- o Does the project benefit all users?

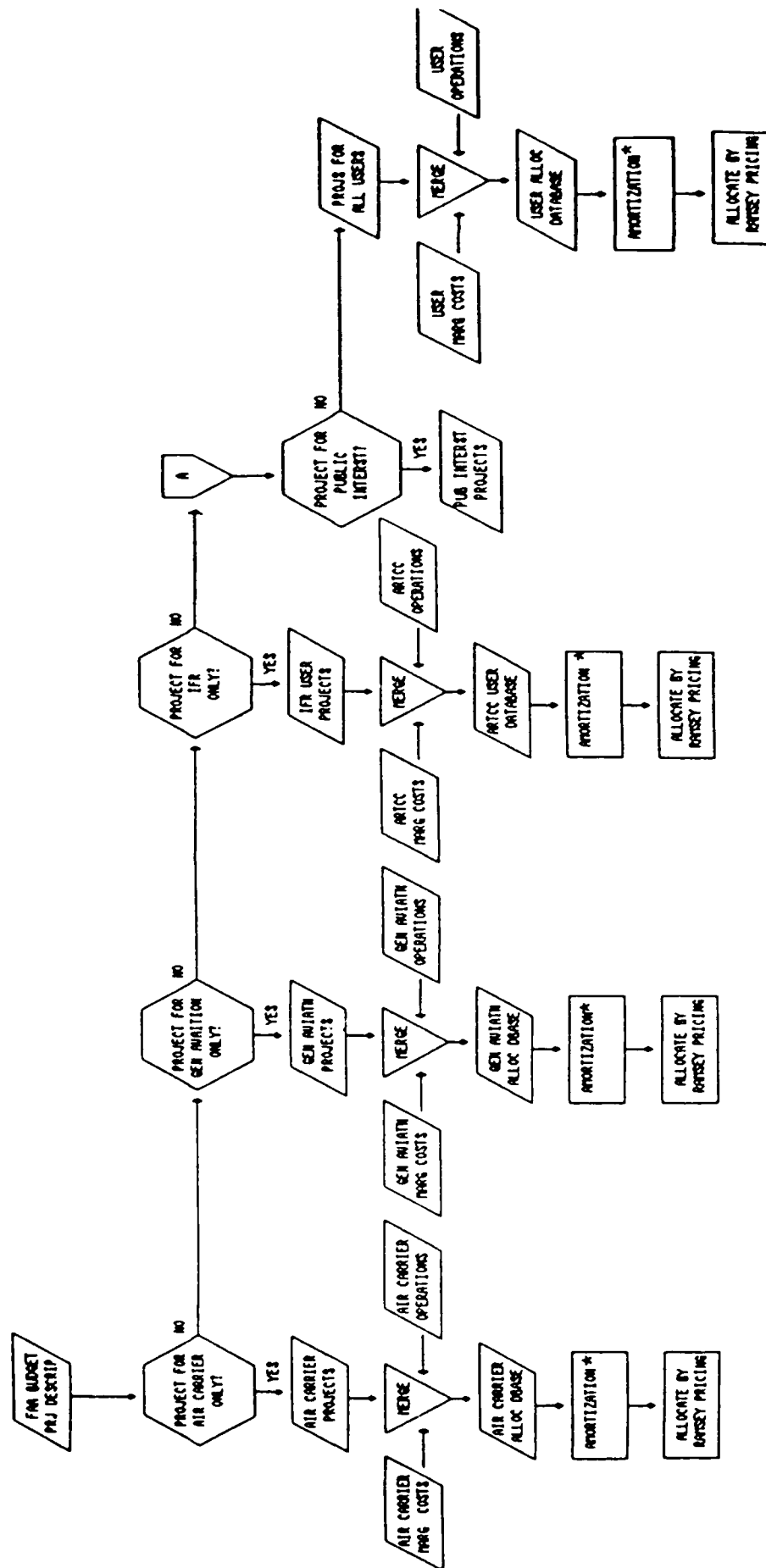
Of the above categories only public sector projects are assigned directly to that category. Other types of projects go through subsequent allocation steps which are quantitatively different for any project type but are conceptually the same. As shown in Figure 2.4.1, an air carrier project, for example, is evaluated with respect to air carrier marginal costs, air carrier operations and relative demand elasticities. The project costs and these activity and cost measures are entered into a central database where they are allocated among the air carrier user groups.

2.5.2 Final Allocation of R&D

The resultant cost allocations are shown in Table 2.5.1. Air carrier R&D project costs are assigned largely to domestic passenger and commuter air carriers. General aviation R&D project costs are allocated largely to GA-piston and GA-turbine users. IFR user R&D project costs are allocated mostly to domestic passenger and commuter air carriers, GA-turbine and military users. The allocation of R&D projects for all users

Figure 2.4.1.

CATEGORIZATION AND ALLOCATION
OF F&E R,F,&D PROJECTS



* Amortized in future years only.

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Table 2.5.1

FINAL ALLOCATION OF R&D DIRECT COSTS TO USERS
REGULATORY COSTS ALLOCATED TO USERS
1985 FISCAL YEAR

13-Aug-86

USERS	GA PROJECTS	PROJECTS FOR ALL USERS	(*) IFR PROJECTS	AIR CARRIER PROJECTS	TOTALS
AIR CARRIER-DOMESTIC	\$0	\$13,760,494	\$6,829,061	\$137,425,998	\$158,015,553
AIR CARRIER-INTL	\$0	\$687,915	\$372,520	\$6,870,207	\$7,930,643
AIR CARRIER-FREIGHT	\$0	\$994,791	\$467,645	\$9,934,970	\$11,397,406
COMMUTER	\$0	\$4,988,520	\$1,350,685	\$49,740,436	\$56,071,562
AIR TAXI	\$610,115	\$1,350,216	\$416,731	\$0	\$2,377,063
GENL AVIATION-PISTON	\$2,296,950	\$5,027,473	\$563,073	\$0	\$7,887,496
GENL AVIATION-TURBO	\$1,878,027	\$4,156,168	\$2,584,986	\$0	\$8,619,100
ROTORCRAFT	\$285,899	\$632,709	\$0	\$0	\$918,608
GOVERNMENT	\$131,763	\$291,599	\$91,850	\$0	\$515,212
MILITARY	\$0	\$7,583,207	\$3,684,150	\$0	\$11,267,357
TOTAL TO USERS	\$5,202,754	\$39,465,092	\$16,360,542	\$203,971,612	\$265,000,000
R&D PUBLIC INTEREST PROJECTS					\$0
TOTAL R&D					\$265,000,000

(*) Allocation based on ARTCC marginal costs and activity.

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Table 2.5.2

FINAL ALLOCATION OF R&D DIRECT COSTS TO USERS
REGULATORY COSTS ALLOCATED TO PUBLIC
1985 FISCAL YEAR

13-Aug-86

USERS	GA PROJECTS	PROJECTS FOR ALL USERS	(*) IFR PROJECTS	AIR CARRIER PROJECTS	TOTALS
AIR CARRIER-DOMESTIC	\$0	\$5,877,452	\$6,829,061	\$137,425,998	\$150,132,511
AIR CARRIER-INTL	\$0	\$293,826	\$372,520	\$6,878,207	\$7,536,553
AIR CARRIER-FREIGHT	\$0	\$424,900	\$467,645	\$9,934,970	\$10,827,515
COMPUTER	\$0	\$2,127,385	\$1,350,685	\$49,740,436	\$53,218,346
AIR TAXI	\$618,115	\$576,711	\$416,731	\$0	\$1,603,558
GENL AVIATION-PISTON	\$2,296,950	\$2,172,278	\$563,073	\$0	\$5,032,301
GENL AVIATION-TURBO	\$1,878,027	\$1,775,203	\$2,584,906	\$0	\$6,238,136
ROTORCRAFT	\$285,899	\$270,246	\$0	\$0	\$556,145
GOVERNMENT	\$131,763	\$124,549	\$91,850	\$0	\$348,163
MILITARY	\$0	\$3,238,978	\$3,684,150	\$0	\$6,923,128
TOTAL TO USERS	\$5,202,754	\$16,881,448	\$16,360,542	\$203,971,612	\$242,416,356
R&D PUBLIC INTEREST PROJECTS					\$22,583,645
TOTAL R&D					\$265,000,000

shows a distribution similar to that for IFR users except that GA-piston users also are allocated a significant share of costs.

2.6 Airport Grants

This section reports the results of the allocation of airport grants to users of the national airport system. Every year, the FAA makes grants to local airport authorities to improve facilities and equipment and for other purposes. The current grant program, known as the Airport Improvement Program (AIP), is governed by the Airport and Airway Improvement Act of 1982 (Tax Equity and Fiscal Responsibility Act of 1982, Public Law 97-248).

To be eligible for a grant, an airport must be publicly owned, privately owned but designated by the FAA as a reliever airport, or privately owned but have scheduled service amounting to at least 2,500 annual enplanements. The airport must also be included in the National Plan of Integrated Airport Systems (NPIAS). Currently, the NPIAS contains approximately 3,600 airports. There are three general categories of eligible projects: airport planning, airport development, and noise compatibility programs; the majority of the money is spent on airport development.¹¹

The 1982 Act defines four eligible airport categories:¹²

- o Primary airports--those enplaning .01 percent of the total passengers enplaned annually.
- o Commercial service airports--those publicly owned airports which enplane 2,500 or more passengers annually.

- o Reliever airports--those airports designated by the FAA as having the function of relieving congestion at a primary or commercial service airport.
- o Other airports--the remaining airports were not specifically defined in the Act but are referred to as general aviation airports.

The remainder of the section reviews the theory and concepts of the airport grant allocation and the specific allocations made to each of the four types of airports for 1984.

2.6.1 Theory and Concepts

There are three main topics that are important in understanding the allocation of airport grants. The first relates to whether airport grants should be amortized since the majority of them are for facilities and equipment. The second relates to how best to identify the beneficiaries of grants made to airports throughout the United States. The third issue relates to how grants made to benefit more than one user group should be allocated among those user groups. Each of these issues is addressed in turn below.

2.6.1.1 Amortizing versus Expensing Airport Grants--Grants have two conflicting characteristics. First, most grants are made to defray the costs of F&E projects undertaken at airports. In general, it is desirable to amortize capital programs over their economic lives in order to match consumption of benefits with capital recovery.

However, grants are cash outlays made by the FAA to airport sponsors. The resulting facilities and equipment are owned and

operated by those sponsors. In effect, FAA acts as a tax collector and redistribution agent. While the ultimate use of grant money is, for the most part, to defray the cost of capital equipment, from the standpoint of the FAA budget, grants are cash outlays which are fully expended in a single year. Furthermore, nothing is known about the durability of capital funded by grants.

For these reasons, grants are properly expensed in the FAA budget. This treatment is consistent with previous cost allocation studies.

2.6.1.2 Overview of Airport Grant Methodology--Shown in Figure 2.6.1 is the general methodology utilized to allocate airport grants in 1984. All grants were segregated into two categories:

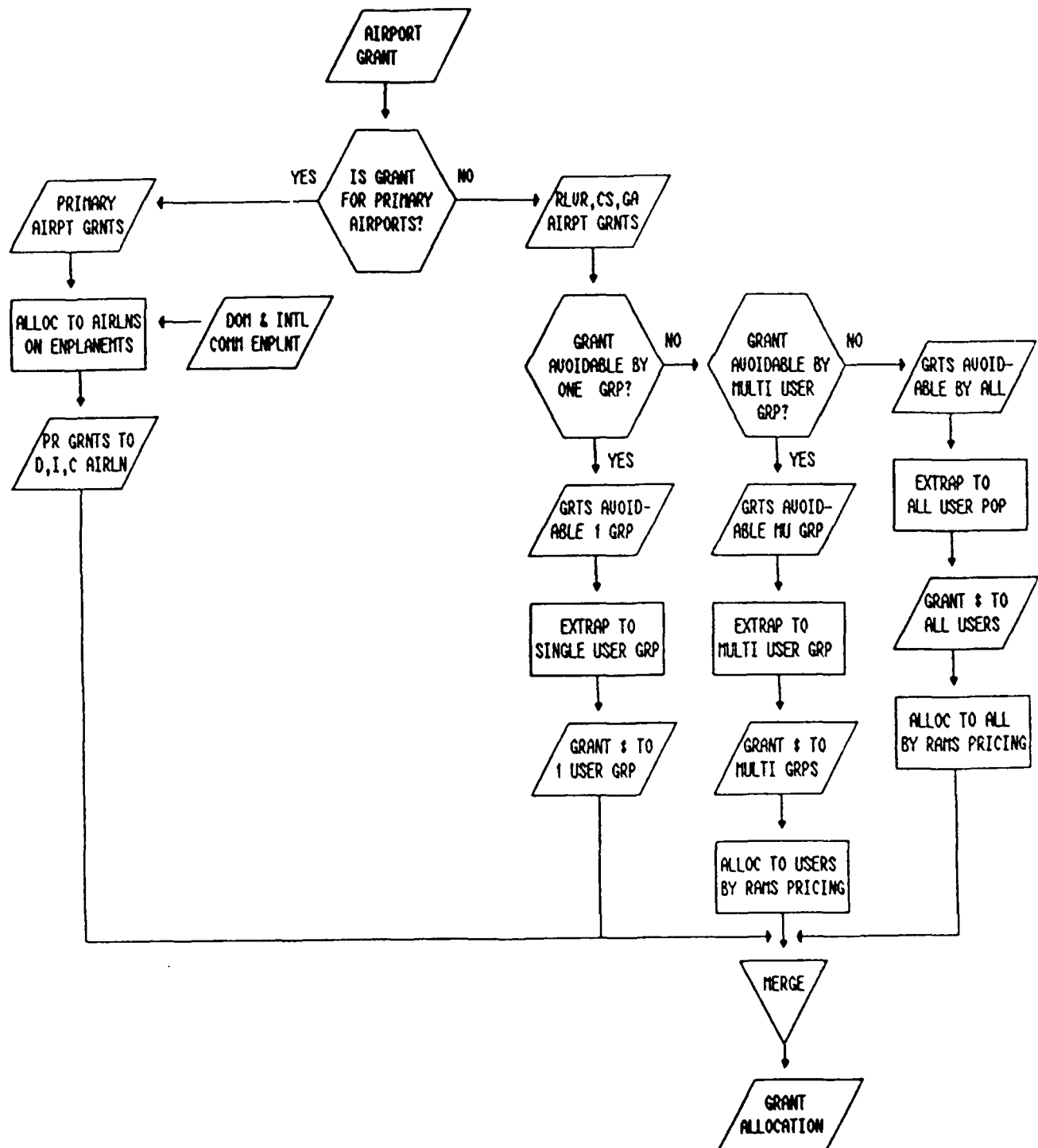
- o Primary airport grants,
- o All other airport grants.

The 1982 law specifies that the former set of grants be allocated among air carriers according to their enplanements. Therefore, estimates of domestic, international, and commuter airline enplanements for 1985 were used as the basis for apportioning grants among airline users. An adjustment was made to reflect the fact that commuters are relatively less intensive users of primary airports than either domestic or international air carriers.¹³

The procedure used to allocate grants made to reliever, commercial service and general aviation airports was more complex. The ultimate beneficiaries of these grants are not revealed in the 1982 law. It was therefore necessary to examine

Figure 2.6.1

AIRPORT GRANT ALLOCATION METHOD



a sample of grants made to these three airport types in order to better understand the distribution of benefits.

The distribution of non-primary grants among users was developed based on four years of data: 1980, 1982, 1983 and 1984.¹⁴ This multi-year sample insured that the resulting distribution was representative of the grant process, and would not be dominated by a single year's results.

A stratified random sample of grants was drawn for each of the three types of airports. Each type of grant was further subdivided into "large" and "small" categories to account for possible differences in the size of grants made to accommodate the needs of different users.¹⁵

Once a statistically valid sample of grants was drawn, the justification statements in each grant application were evaluated in detail. This evaluation included discussion with personnel at the regional level and included the following steps:

- o The first step was to identify the beneficiaries of the grant from the justification statements and from discussions with regional personnel. No costs of a grant were attributed to any user groups not benefitting from it.
- o The next step was to determine whether the project funded by the grant would have been undertaken in the absence of one or more user groups. This step is akin to identifying the avoidable cost of the grant. If the grant would have gone forward even in the absence of a beneficiary, none of the costs should be attributed to that user group.

- o This process resulted in two types of grant allocations. In some cases, grants were assigned to only a single user group. In others, multiple users were equally responsible for the grant. In the latter case, the amount of the grant was distributed among joint beneficiaries based on airway activity, marginal costs and relative demand elasticities.

The results of this grant allocation process were then extrapolated to the population of all grants in 1985.

What follows is a brief discussion of this treatment of the joint airport grants.

2.6.1.3 Treatment of Joint Airport Grants--The allocation of joint airport grants is based on the costs and activities at air traffic operating sites. The implicit assumption is that the output of airport grant projects is an integral part of the airway system under the control of the FAA.

Ultimately, selecting the proper method to allocate joint airport grants depends upon whether or not airport services are separable from the air traffic control services owned and operated by the FAA. There are at least two reasons to believe that grants produce separable services:

- o Even though they are subject to certain Federal regulations, airports are owned and operated by independent entities.
- o Users may not consume airport services in the same way they consume airway services. As a result, the relative shares of joint airport grants may not be well

represented by an allocation formula developed based on airway consumption.

However, there are three offsetting factors which make the allocations based on airway statistics the preferred method. First, even though airports are owned and operated by independent entities, users consume airport and airway services together. From the standpoint of the users, there is a single system.

Second, while it is true that airway facilities use patterns are not perfect measures of the use of airports, it is also true that only those users who share responsibility for a joint grant are subject to the allocation. Preceding steps in the methodology ensure that joint costs are assigned among users exhibiting avoidable costs. Any allocation of joint costs is arbitrary, but the present method minimizes the distortion in markets.

Finally, one chief concern about any allocation method is whether it distinguishes between the needs of different user groups. For example, airlines flying 747 aircraft require far different facilities than do aviators flying single-engine piston aircraft. It turns out that very few grants were allocated across such a broad spectrum of users. All primary grants were allocated among passenger airlines. The remaining grants were allocated among users based upon a sample of grants for the years 1980, 1982, 1983 and 1984. The distribution among user groups is shown in Table 2.6.1. A quick perusal of the table indicates that for the most part, projects where carriers were identified as beneficiaries (the projects would not have been undertaken without them) involve only air carriers. Projects with general

aviation beneficiaries do not involve air carriers. Only 4.5 percent of the dollars allocated from the sample were jointly attributable to all users.

Table 2.6.1

PERCENT OF GRANTS ALLOCATED AMONG USER CATEGORIES

<u>User Category</u>	<u>Primary Grants</u>	<u>All Other Grants</u>
Air Carriers Only	100%	10.56%
General Aviation Only	0	75.33%
Military Only	0	0
GA + Commuters	0	6.99%
GA + Military	0	2.61%
All Users	0	4.51%

2.6.2 Results

What follows is a review of the results of the allocations for each of the four types of airports for 1985 as summarized in Table 2.6.2.

- o Primary Airport Grants--These grants are assigned to users based upon enplanement data, adjusted for the intensity of use at the 70 primary airports in the United States in 1985.¹⁶ As would be expected, domestic air carriers enplane the majority of passengers at these airports and therefore are assigned the greatest share of costs.
- o Reliever Airport Grants--The majority of the reliever grants are allocated to general aviation piston users.

Table 2.6.2

ALLOCATION OF 1985 AIRPORT GRANTS

USERS	Primary Airports	Commercial Service Airports	Reliever Airports	General Aviation Airports
AIR CARRIER-DOMESTIC	\$467,173,150	\$7,920,703	\$854,517	\$1,547,373
AIR CARRIER-INTL	\$35,029,850	\$395,972	\$42,719	\$77,356
AIR CARRIER-FREIGHT	\$0	\$485,351	\$61,776	\$111,865
COMPUTER	\$22,746,042	\$27,390,770	\$309,287	\$42,045,566
AIR TAXI	\$0	\$1,155,602	\$679,996	\$3,382,367
GENL AVIATION-PISTON	\$0	\$7,486,904	\$71,264,223	\$85,235,001
GENL AVIATION-TURBO	\$0	\$29,006,475	\$45,149,795	\$54,992,035
ROTORCRAFT	\$0	\$308,694	\$6,386,731	\$71,148
GOVERNMENT	\$0	\$1,361,593	\$2,518,154	\$79,595
MILITARY	\$0	\$4,562,931	\$3,128,631	\$1,766,830
	<u>\$524,949,041</u>	<u>\$80,082,994</u>	<u>\$130,395,829</u>	<u>\$189,309,136</u>

This result is not surprising given their relatively intensive use of reliever facilities.¹⁷

- o Commercial Service Airport Grants--The examination of justification statements for grants made to these airports indicated that there were three primary beneficiaries: GA-turboprop and turbojet operators, GA-piston operators, and commuter airlines. Government operators also were substantial beneficiaries of grants made to these airports.
- o General Aviation Grants--Not surprisingly, general aviation-piston and turboprop and turbojet users account for virtually all of the grant monies. These operators are by far the most intensive users of these airports.

2.7 Allocation of Other Direct Costs

This section describes the methodology used to allocate other direct costs in the FAA budget. Direct costs are those which can be attributed to users based on their use of FAA resources. The cost categories described in this section do not easily fit into other categories previously described. The general methodologies employed are similar to those described in previous sections.

2.7.1 Theory and Concepts

Table 2.7.1 describes the five cost categories and how they are allocated. In all cases, users are assigned the avoidable costs of FAA resources they consume. In summary:

Table 2.7.1

OTHER DIRECT COST CATEGORIES

<u>Budget Category</u>	<u>Description</u>	<u>Treatment</u>
Aircraft Loan Guarantees	Residual costs of guaranteeing aircraft loans for airlines; program now expired.	Allocated as a joint cost among domestic, freight, and commuter air carriers.
"Navaid" Maintenance	Cost of maintaining Nav aids and other FAA facilities and equipment not located at FAA operating sites.	Allocated as a joint cost among all users.
Aviation Standards--O&M*	Cost of inspecting aircraft, aircraft operators and aviation facilities.	Allocated to users based on inspector time sheets.
Aviation Standards--Aviation Security*	Cost of airport security programs.	Allocated as a joint cost among air carriers.
Administration of Airports--Safety Regulation*	Cost of administering airport safety regulations and programs.	Allocated as a joint cost among users.

* Allocated to the public sector regulatory costs are deemed to be public interest activities.

- o Aircraft loan guarantees are allocated among their prime beneficiaries--domestic, freight and commuter air carriers.
- o NAVAID (and other) maintenance is allocated among all users as a joint cost based upon each user group's activity, marginal costs, and relative demand elasticities exhibited at all FAA facilities.
- o Aviation standards O&M is allocated among all users based on the allocation of inspector time; joint costs are allocated among users based on activity, marginal cost and relative demand elasticities exhibited throughout the airway system.
- o The aviation security function in the aviation standards budget is allocated among air carriers as a joint cost because they are the chief beneficiaries of these programs.
- o The safety regulation function in the administration of airports is allocated among all users as a joint cost based upon activity, marginal cost and relative demand elasticities exhibited throughout the airway system.

It should be noted that the last three items in Table 2.7.1 all pertain to regulatory activities. Under the scenario when all regulatory costs are allocated to the public sector, these costs are not allocated to users.

2.7.2 Allocations to Users

Table 2.7.2 shows the distribution of these direct cost categories to users in 1985. These results assume that regulatory costs are properly allocated to users. Under the

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Table 2.7.2

FINAL ALLOCATION OF OTHER DIRECT COSTS TO USERS
1985 FISCAL YEAR

13-Aug-86					
USERS	AC LOAN GUARANTEE	AVIATION STANDARDS-04M	AVIATION STDS AV SECURITY	NAVAID MAINTENANCE	TOTALS
AIR CARRIER-DOMESTIC	\$0	\$34,155,684	\$10,181,500	\$130,080,320	\$182,417,504
AIR CARRIER-INTL	\$0	\$1,708,351	\$508,994	\$6,902,918	\$9,120,263
AIR CARRIER-FREIGHT COMMUTER	\$0	\$2,468,524	\$736,854	\$9,982,273	\$13,186,850
	\$0	\$25,652,454	\$3,685,127	\$49,977,264	\$79,314,845
AIR TAXI	\$0	\$8,838,835	\$0	\$13,548,805	\$21,587,640
GENL AVIATION-PISTON	\$0	\$16,124,886	\$0	\$42,728,059	\$58,844,865
GENL AVIATION-TURBO	\$0	\$13,893,538	\$0	\$41,785,258	\$55,598,796
ROTORCRAFT	\$0	\$2,069,571	\$0	\$6,348,951	\$8,418,521
GOVERNMENT	\$0	\$956,283	\$0	\$2,926,861	\$3,882,343
MILITARY	\$0	\$6,584,576	\$0	\$76,894,048	\$82,678,623
TOTAL TO USERS	\$0	\$111,652,620	\$15,111,674	\$388,285,957	\$515,050,251

scenario that regulatory costs should be assigned to the public sector, user allocations would be zero for the aviation standards and airports administration categories.

2.8 Indirect Cost Categories

This section describes the methodology used to allocate indirect cost categories in the FAA budget to users of the airport and airway system. Included in this major cost category are the overhead items contained in the FAA budget including headquarters administration, regional administration, and planning activities related to the operation of both the airport and airway systems. First, the theory and concepts related to the proper methods for accounting for overhead items are presented. Then, the methods selected for this study are discussed in detail. Finally, the allocations to final cost categories in the FAA budget are presented.

2.8.1 Theory and Concepts

The problem addressed in this section is how to properly account for indirect costs in the FAA budget. These costs must be accounted for if users are to be allocated the full costs of their consumption of FAA services. The task at hand is to develop a logical method for identifying those final cost categories serving users directly which are supported by indirect cost categories in the FAA budget.

The common cost accounting procedures for allocating indirect costs to direct cost categories are: the one-step allocation, the sequential allocation, and the cross-allocation method. The accuracy level desired and financial and practical

considerations dictate the selection of a particular methodology to be used.

Using the one-step or direct allocation method, the costs of a support department (or cost category) are allocated directly to final cost categories--those categories serving users directly. This is the simplest allocation method but is the least accurate. It does not recognize the interdependence among support departments and therefore excludes from allocation many of those cost categories contained in the FAA budget. Only support categories directly related to final cost categories would be included under this allocation scheme. Such major cost categories as headquarters administration would be excluded.

The sequential or step-down allocation method recognizes that some support departments provide services for other support departments. The process begins with the allocation of costs of a support department providing the most universally used services, followed in order by the support department next most widely used, and so on. This method is more thorough than the direct allocation method, but still limits the centers that can be allocated to those which can be directly related to FAA final cost categories.

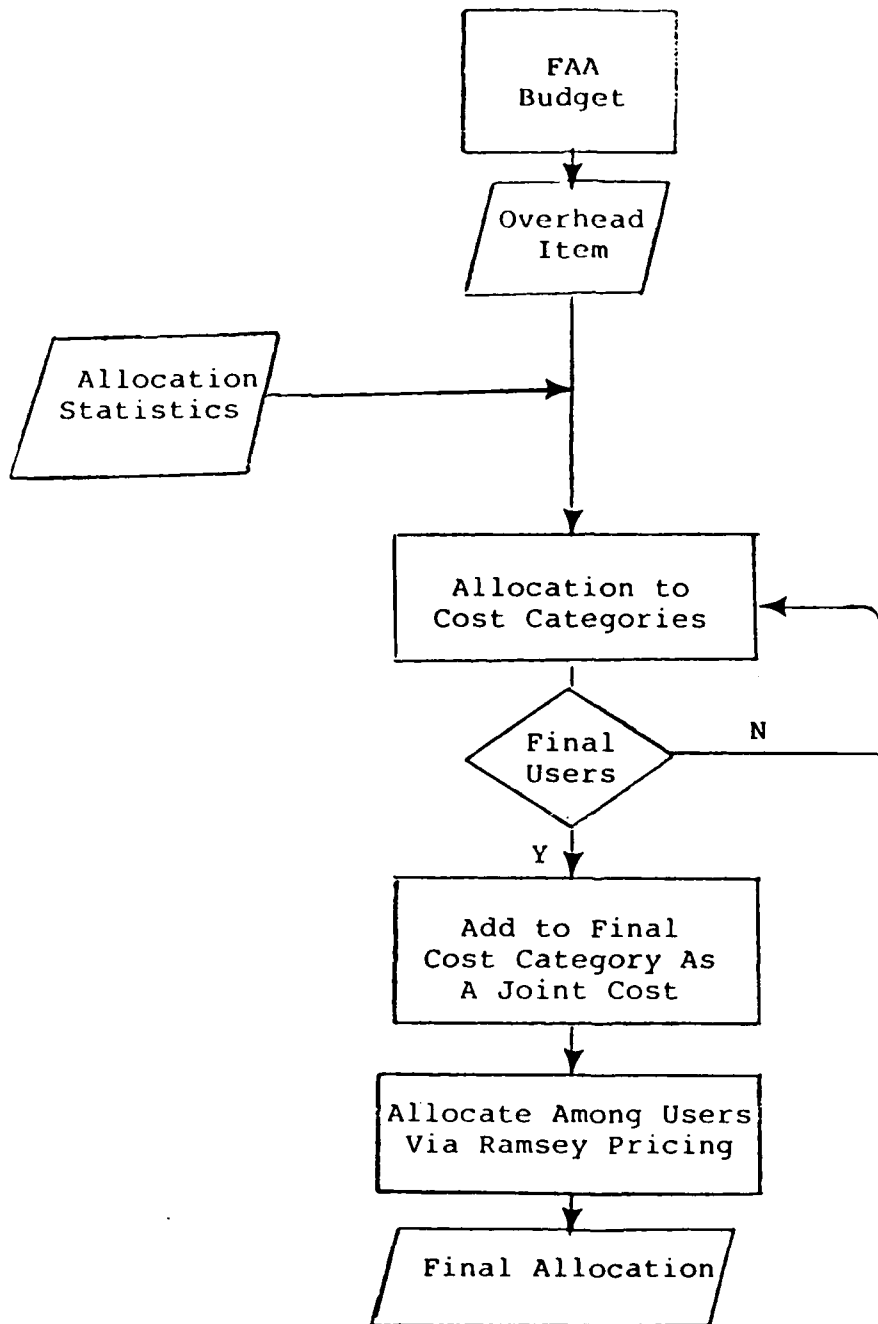
The cross-allocation or multiple reporting method more appropriately recognizes the interdependence of support departments. Each support department is charged a portion of the costs of each of the other departments from which it received support. Multiple steps or iterations of the cross-allocation process are required in order to arrive at an accurate solution.

In order to select the methodology for this study, interviews were held with representatives of various FAA headquarters and regional departments. In each case, the structure and responsibilities of organizational units within the FAA were analyzed in order to relate organizational outputs to those groups receiving benefits. In this way, the relationships between departments within the agency were identified. In constructing these inter-relationships, authoritative sources on indirect cost allocation and cost accounting were reviewed, including: standards issued by the Cost Accounting Standards Board (CASB), and relevant Office of Management and Budget (OMB) circulars.

Based on the review of the issues, the cross-allocation or multiple apportionment method was adopted as being the most accurate for this assignment. The basic methodology is shown in Figure 2.8.1. Overhead items are identified in the FAA budget. Based upon the interviews conducted with the agency, allocation statistics are selected for each of the overhead items. These allocation statistics allow indirect costs to be distributed on a basis which allots costs in relation to the service levels rendered by each indirect department. Examples of this would be the number and types of airport grants processed or the number of full-time equivalent employees supported by an indirect category. Using the allocation statistic, the overhead item is allocated to other cost categories. In those cases where the receiving cost category is not directly related to final users, additional iterations of the model are necessary. These iterations continue until all of the layers of overhead are related directly to final

Figure 2.8.1

METHODOLOGY TO ALLOCATE OVERHEAD COSTS



cost categories--those directly related to users. Once this is accomplished, the overhead allocations are added to the direct costs in each of the final cost categories and allocated as a joint cost among users.

2.8.2 Application of Cross-Allocation Methodology to the FAA Budget

There are six major indirect cost categories in the FAA budget. Each of them is briefly described below:

- o Administrative Support: Included in administrative support are several line items from the FAA budget: development and direction; direction and staff support; headquarters administration; and miscellaneous items including payments to NOAA. This overhead item is related to other cost categories in the FAA budget based upon full-time equivalent employees. This recognizes that the majority of the support provided by administrative services is a direct function of the number of people in other departments within the agency.
- o Centralized Training: This cost category represents the central training activities undertaken in Oklahoma City which support the initial and continuing education programs in the air traffic service, the aviation standards branch, and other departments within the agency. These overhead costs are allocated to other departments based upon the student enrollment in those departments.

- o Installation and Material Services: This activity includes supply support for the National Airspace Systems and agency aircraft, procurement activities for the agency, contracting and management of property, transportation services, administrative services, and administrative telecommunications. These indirect cost categories are related to other departments within the agency based upon full-time equivalent employment in those other departments. This allocation method recognizes that the majority of costs incurred in the I&M category relate to administrative functions which are best represented by this type of allocation.
- o Administration of Airport Grants: Included in this category is approximately 65 percent of the total airport administrative budget. These funds are then distributed in proportion to the total number of grants in each of the four airport grant categories: primary, commercial service, reliever, and general aviation. Use of this allocation statistic recognizes that the cost of administering an airport grant is independent of the size of that grant.
- o Aviation Standards--Other: Included in this category are all of the aviation standards functions with the exception of operations and maintenance, and airport security. This indirect cost category is related to other FAA departments based upon full-time equivalent employment in those departments. This allocation method recognizes that aviation standards provide

inputs to virtually every other department within the agency.

- o Planning Direction and Evaluation: This category includes the planning and other indirect activities related to administrating the air traffic system. This indirect category is allocated to FSSs, ARTCCs, towers, and TRACONS as a proportion of direct obligations of those departments.

The total budget for these indirect costs is shown in Table 2.8.2.1. It should be noted that the total overhead assigned to users differs depending upon whether aviation standards and airport regulatory functions are assigned to users or to the public interest. In the former case, total overhead in the budget amounted to \$701.7 million, while in the latter overhead amounts to \$572.7 million. The difference between the two scenarios relates to whether regulatory costs are to be recovered from users.

Also shown in Table 2.8.2.1 is the overhead allocated to District of Columbia airports. In Volume 3 of this report, there is an extensive discussion concerning the proper treatment of these airports in the context of the FAA allocation study. There it is demonstrated that these airports are operated as going concerns without the need of additional user taxes. Therefore, the \$51.15 million in operating costs identified in the FAA budget for DC airports should not be recovered through user taxes. The overhead attributable to the administration of these airports over and above the direct costs are identified in Table

Volume 1

Table 2.8.2.1

OVERHEAD ITEMS PAID BY USERS
UNDER TWO SCENARIOS
1985

13-Aug-86

	Overhead Assuming Regulatory Costs Are allocated to Users	Overhead Assuming Regulatory Costs Are allocated to the Public
Administrative Support	\$193,685	\$187,266
Centralized Training	\$182,869	\$97,268
I&M	\$193,367	\$193,367
Admin. of Airport Grants	\$26,616	\$26,616
Aviation Standards-Other	\$131,120	\$0
Planning, Direction, Evaluation	\$68,886	\$68,886
	<hr/>	<hr/>
	\$714,863	\$572,683
Less Overhead Allocated to DC Airports	<hr/> \$11,140 <hr/>	<hr/> \$11,140 <hr/>
Overhead Paid by Users	<hr/> \$783,723 <hr/>	<hr/> \$561,463 <hr/>

* Numbers may not add due to rounding.

2.8.2.1. These costs also need not be recovered through user taxes, but instead should be properly covered by those aviators using the District of Columbia airports. As a result, the total overhead to be paid by all users is somewhat lower than the total overhead identified in the budget with the difference being overhead allocated to District of Columbia airports.

2.8.3 Results

The allocations of both direct and indirect costs are shown in Tables 2.8.3.1 and 2.8.3.2. The former relates the allocations under the assumption that regulatory costs are allocated to users. The latter relates to the case where regulatory costs are assigned to the public interest.

The top section of each table summarizes the allocation of direct costs, while the bottom section summarizes how indirect costs are allocated to direct costs categories, and then to user groups (including the public sector). For example, in Table 2.8.3.1 the direct cost of ARTCC operations total to \$566.1 million in 1985. To this, indirect costs of \$172.6 million are attributed to users of ARTCC's. In the remaining columns, the tables also summarize the total 1985 cost allocations to each user group.

Under either scenario, the largest share is attributable to domestic air carriers (on the order of 40 percent). A second tier of users, evidencing shares of between 12 and 13 percent, includes commuters, operators of GA-piston aircraft, and the military. None of the other groups has a share as high as three percent.

Table 2.8.3.1
1985 ALLOCATION
REGULATORY COSTS ALLOCATED TO USERS

13-Aug-86											
DIRECT COSTS	TOTAL										
	AIR CARRIER DOMESTIC	AIR CARRIER INT'L	AIR CARRIER FREIGHT	COMPUTER	AIR TAXI	GEN. AVIATION PISTON	GEN. AVIATION TURBINE	ROTOR	GOVERNMENT	MILITARY	PUBLIC INTEREST
Public Interest	424,726,917	44	44	44	44	44	44	44	44	45,564,787	419,872,210
Naval Maintenance	4384,285,957	46,982,918	49,982,273	449,977,264	413,548,845	442,728,859	441,783,258	46,316,951	42,935,861	476,094,848	44
Safety Regulation	4126,764,294	42,117,345	43,204,577	429,337,581	44,838,825	416,124,886	413,891,538	42,463,571	456,243	46,584,576	44
ARTCCs	4566,877,841	412,528,188	415,717,284	445,393,847	414,886,899	425,133,347	446,877,178	44	43,487,832	4123,822,126	44
Towers	4113,885,469	44,812,348	4488,181	418,898,938	45,429,842	442,458,865	414,143,443	44,434,896	42,413,049	416,567,183	44
TRACONS	4525,732,219	448,773,749	415,548,171	4184,927,999	418,373,271	479,144,183	412,773,667	47,154,859	42,478,498	443,873,739	44
FSSs	4239,534,634	418,496,951	4464,348	414,236,198	414,683,848	4137,681,832	428,442,478	418,495,141	43,117,985	427,264,532	44
TOTAL OPS BUDGET	41,984,136,538	4632,875,674	431,454,843	4253,963,818	469,999,898	4353,478,283	4189,835,586	434,582,618	414,578,938	4339,866,911	419,872,210
FILE	41,258,000,000	4671,383,288	434,333,633	4215,271,837	427,648,932	467,791,656	4117,316,883	44,125,988	46,816,973	4162,219,649	44
RIP	4265,000,000	4158,815,553	47,938,643	456,871,562	42,377,863	47,887,496	48,619,188	4918,688	4515,212	411,287,357	44
AIP GRANTS	4924,737,000	4477,495,742	425,545,897	492,499,665	45,217,964	4163,966,129	4129,144,385	46,766,574	43,959,341	49,458,392	44
TOTAL DIRECT COSTS	44,531,873,538	4189,255,816	4186,857,147	4617,885,283	4185,243,856	4593,143,563	4444,919,713	458,313,788	425,878,464	4322,812,328	419,872,210
INDIRECT COSTS											
Public Interest	46,968,833	44	44	44	44	44	44	44	44	4815,737	46,145,896
Naval Maintenance	4172,983,743	468,783,138	43,838,673	422,888,854	45,964,281	428,785,283	418,258,787	42,794,816	41,288,856	433,496,695	44
Safety Regulation	447,543,646	417,288,786	4864,517	49,737,782	42,528,553	45,791,178	44,917,845	4736,627	4348,139	44,857,473	44
ARTCCs	4172,685,985	472,444,925	43,949,636	414,319,752	44,418,383	45,113,771	427,446,389	44	4973,839	439,861,895	44
Towers	433,256,825	42,528,332	4154,812	43,222,888	43,818,925	418,771,218	44,515,952	42,682,985	4774,493	45,289,859	44
TRACONS	4154,985,898	464,285,843	42,793,851	433,412,548	43,383,192	412,791,776	44,867,557	42,278,343	4661,868	426,453,422	44
FSSs	468,999,267	44,465,718	4197,544	46,856,585	46,212,571	425,563,998	44,696,839	44,464,948	41,328,484	411,597,447	44
TOTAL OPS BUDGET	4657,186,237	4221,785,853	411,828,234	468,748,641	425,429,826	488,817,137	467,982,498	412,987,719	45,388,871	4128,771,728	46,145,896
FILE	412,668,741	44,489,525	4228,441	41,595,999	4432,674	41,633,289	41,331,836	4282,751	493,442	42,438,825	44
RIP	411,357,448	43,952,768	4197,687	41,438,679	4387,856	41,465,875	41,193,879	4181,749	443,763	42,178,313	44
AIP GRANTS	422,598,717	46,979,842	4942,171	43,453,989	4239,136	45,895,276	44,755,533	4168,388	4115,385	4442,328	44
TOTAL INDIRECT COSTS	4783,723,142	4237,847,989	411,954,452	495,229,388	426,489,692	489,818,757	475,243,738	413,512,598	45,553,441	4125,822,386	46,145,896
GRAND TOTAL	45,235,596,672	42,176,818,239	4121,219,468	4713,814,598	4131,733,549	4682,954,321	4528,163,451	463,826,298	438,723,985	4647,634,714	425,217,386
USER GROUP PERCENTS	100.00%	41.54%	2.32%	13.62%	2.52%	13.84%	9.94%	1.22%	0.59%	12.37%	0.44%

Table 2.8.3.2

1985 ALLOCATION

REGULATORY COSTS ALLOCATED TO PUBLIC

13-Aug-86												
DIRECT COSTS	TOTAL	AIR CARRIER DOMESTIC	AIR CARRIER INT'L	AIR CARRIER FREIGHT	COMPUTER	AIR TRAIL	BOAL AVIATION PISTON	BOAL AVIATION TURBINE	RECTOR	GOVERNMENT	MILITARY	PUBLIC INTEREST
Public Interest	424,736,917	0	0	0	0	0	0	0	0	0	15,664,707	119,072,210
Naval Maintenance	4304,285,957	1130,864,320	66,982,910	19,982,273	119,977,264	113,540,005	142,720,859	111,705,250	16,340,951	12,906,861	176,891,644	0
Safety Regulation	1257,004,294	0	0	0	0	0	0	0	0	0	0	1257,004,294
ARTCCs	1566,077,041	1229,520,717	112,520,100	115,717,204	115,393,017	114,006,099	135,133,347	166,077,170	0	13,007,632	1123,622,126	0
Towers	1113,005,469	14,012,300	1576,304	1400,101	110,090,930	19,429,044	142,450,055	114,143,403	14,434,076	12,113,009	116,567,103	0
TRACONS	1525,732,219	1201,620,092	14,773,749	115,540,171	1104,927,999	110,373,271	179,440,103	112,773,667	17,194,859	12,078,490	143,073,739	0
FSSs	1239,534,634	110,496,951	1464,340	1016,146	114,236,190	114,603,040	137,601,632	120,442,470	110,495,141	13,117,905	127,264,532	0
TOTAL OPS BUDGET	12,115,256,530	1507,730,490	129,237,499	142,904,053	1224,629,437	161,961,063	137,353,477	1173,941,960	132,433,047	113,622,653	132,442,335	1276,956,504
FILE	11,350,000,000	1671,303,200	134,333,633	117,092,110	1215,271,037	127,644,932	167,791,656	1117,316,003	14,125,900	16,016,973	1162,219,609	0
RID	1255,000,000	1150,132,511	17,536,553	110,027,515	153,210,346	11,603,550	15,032,301	16,230,136	1556,145	1340,163	16,923,120	122,503,645
AIP BUDGETS	1924,737,000	1471,495,742	125,545,097	1650,991	192,499,665	15,217,964	1163,966,129	1129,140,305	16,756,574	13,959,341	19,450,392	0
TOTAL DIRECT COSTS	11,662,993,530	11,006,750,023	1106,653,502	1102,202,679	1905,614,406	196,431,517	1574,163,563	1420,645,211	147,001,666	123,947,132	1511,003,522	1299,504,149
INDIRECT COSTS												
Public Interest	15,259,201	0	0	0	0	0	0	0	0	0	1616,333	14,642,868
Naval Maintenance	131,183,702	146,003,125	12,299,790	13,325,715	116,650,529	14,513,940	116,054,253	113,091,610	12,115,230	1974,052	125,351,650	0
Safety Regulation	142,555,736	0	0	0	0	0	0	0	0	0	0	142,555,736
ARTCCs	1143,010,440	159,943,757	13,269,000	14,104,071	111,053,267	13,657,962	14,352,205	122,649,644	0	1606,230	132,330,529	0
Towers	127,306,220	12,037,400	1146,544	1223,015	12,505,947	12,397,045	19,367,247	13,596,420	12,144,643	1613,606	14,212,745	0
TRACONS	1127,105,971	152,494,054	12,204,200	14,037,620	127,310,515	12,700,722	110,041,670	13,325,606	11,062,002	1541,145	121,620,652	0
FSSs	154,039,950	13,493,300	1154,532	1271,613	14,737,799	14,059,004	120,916,766	16,003,243	13,492,770	11,037,664	19,072,291	0
TOTAL OPS BUDGET	1531,199,301	1163,972,523	14,155,042	111,963,641	163,120,056	110,130,371	161,532,221	150,309,603	19,615,453	13,973,505	193,220,200	147,190,605
FILE	19,571,911	13,330,940	1166,521	1240,005	11,005,615	1250,041	11,235,735	11,006,067	1153,157	170,506	11,435,637	0
RID	14,501,159	12,905,970	1149,275	1215,066	11,000,755	1292,992	11,100,320	1901,073	1137,296	163,276	11,645,529	0
AIP BUDGETS	123,250,771	17,109,195	1523,209	142,004	13,553,224	1246,637	16,063,205	14,091,007	1165,230	1110,764	1450,130	0
TOTAL INDIRECT COSTS	1572,603,142	1177,470,643	10,994,120	112,462,395	168,967,650	110,996,041	169,939,461	157,100,531	110,071,142	14,226,130	197,159,495	147,190,605
GRAND TOTAL	15,225,596,672	12,004,220,667	1115,647,709	1114,745,075	1654,582,136	1115,420,350	1644,103,045	1485,753,761	157,992,009	138,173,263	1500,243,017	1346,700,033
USER GROUP PERCENTS	100.000	39.435	2.215	2.194	12.505	2.205	12.305	9.205	1.115	0.545	11.625	6.625

Section 3.0

MINIMUM GENERAL AVIATION COST ALLOCATION

3.1 Introduction and Rationale for Avoidable-Cost Methodology

The full cost allocation in Section 2.0 applies to an aviation system which serves the needs of commercial air carriers, the military (and other government users), and general aviation. It recognizes that some system costs truly are joint costs, but must be allocated among the various user groups. This allocation is accomplished through a Ramsey Pricing formula, which minimizes the economic distortions which will result from taxes based on the allocation of joint costs.

The requirements of commercial aviation have a strong influence on the numbers and types of jointly-used facilities and services currently provided by the FAA. Therefore, some may argue that a more accurate perspective on the impact of general aviation on the FAA can be gained by generating a lower-bound estimate of the costs which it imposes and comparing that estimate to general aviation's share of the full cost allocation. This lower-bound estimate will be termed the minimum general aviation allocation. The fundamental difference between the two allocations is that the full cost allocation assigns general aviation users a portion of costs that they share with other users while the minimum GA system allocates none of these joint costs to general aviation.

The minimum general aviation system allocation rests on the theoretical principle of avoidable cost. Specifically, the allocation is an answer to the question: What costs could the FAA avoid if general aviation did not exist? The rationale for employing the avoidable cost method is essentially the same as it was for employing this method in the full cost allocation--it is the best practical method of estimating long-run marginal cost. A more detailed discussion of this issue has already been presented in Section 2.0.

The specific methods by which avoidable-cost analysis is applied to allocate the costs of a minimum GA system are detailed in Section 3.2. However, three basic guidelines are followed:

- 1) Only costs which can be attributed solely to general aviation are included in the minimum system allocation; all joint costs shared with other users are omitted. This guideline is the major point of departure from the full cost allocation methodology.
- 2) The determination as to whether or not costs associated with a particular facility should be included in the minimum allocation is based on current FAA safety criteria for the establishment of that type of facility.
- 3) Estimates of costs which depend on the level of traffic are derived from the econometric analysis of the marginal costs of general aviation traffic.

It is important to note that the methodology employed in the present study is different from that used in the 1978 cost

allocation study.¹⁸ The present study develops an allocation based on existing technology and current FAA safety criteria. It does not set forth a hypothetical system based on engineering criteria, as did the 1978 study. Thus, the studies employed two distinctly different methodologies. In the 1978 study, the minimum system as a percentage of the total FAA budget was 13.8 percent of the budget. In the present study, the FY1985 minimum GA allocation is estimated to be between 11.1 and 10.6 percent depending upon whether users are allocated regulatory costs.

3.2 Analysis of Minimum GA System Components

The components of the minimum GA system can be placed into six categories:

- 1) Overhead,
- 2) Capital Projects which benefit only General Aviation,
- 3) Flight Service Stations,
- 4) Air Route Traffic Control Centers,
- 5) Terminal Navigation Equipment,
- 6) Terminal Control Facilities.

Each category required a different method for estimating its associated minimum GA system costs. These methods will be discussed individually below. The flowchart in Figure 3.2.1 may be helpful as a reference during the discussion. The analysis of each of the first five categories is shown as a separate branch (moving from left to right), while the terminal control facilities analysis is represented through the interconnection of the last two branches (towers and TRACONS).

Figure 3.2.1

MINIMUM GA SYSTEM ALLOCATION

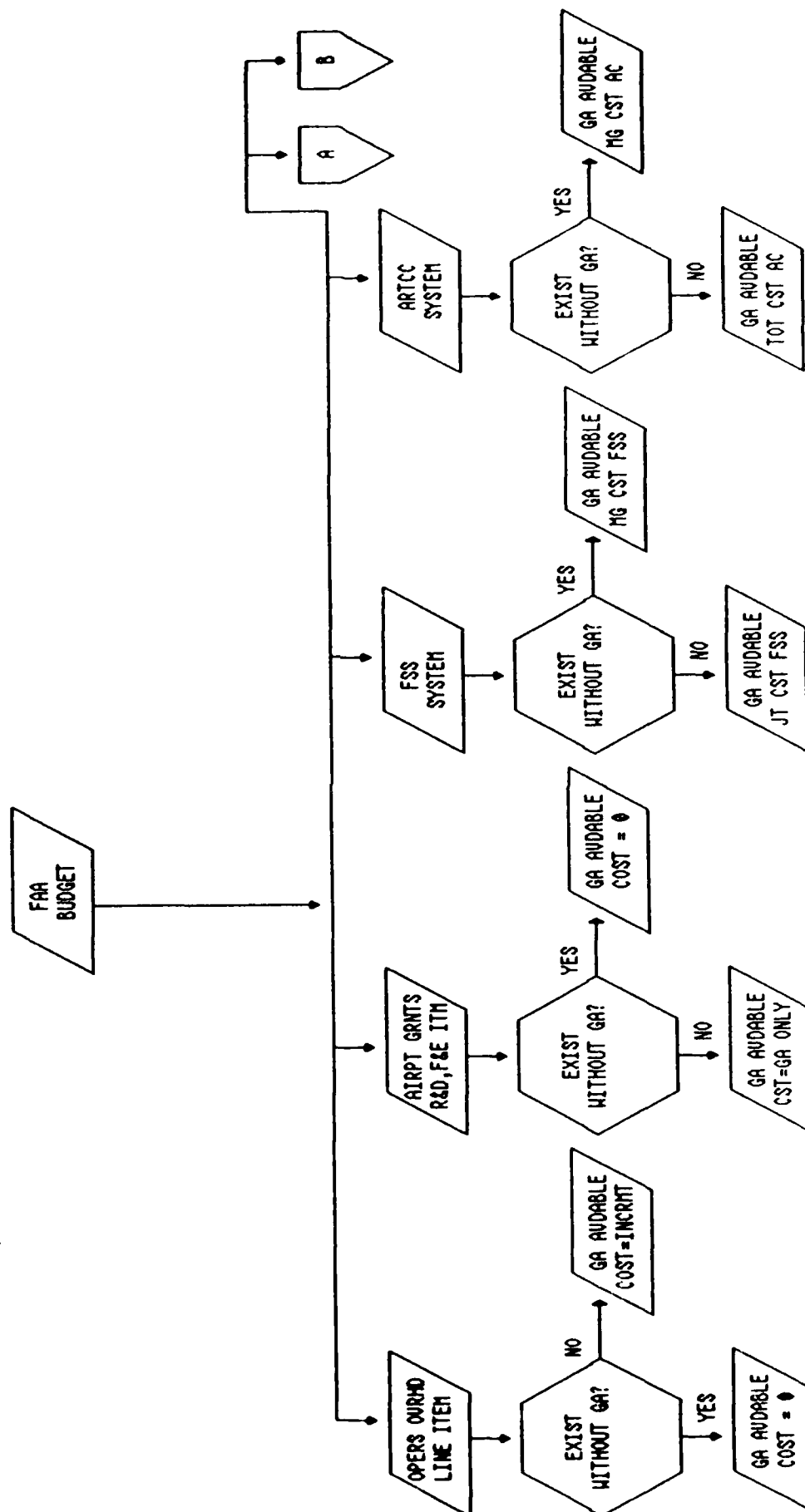
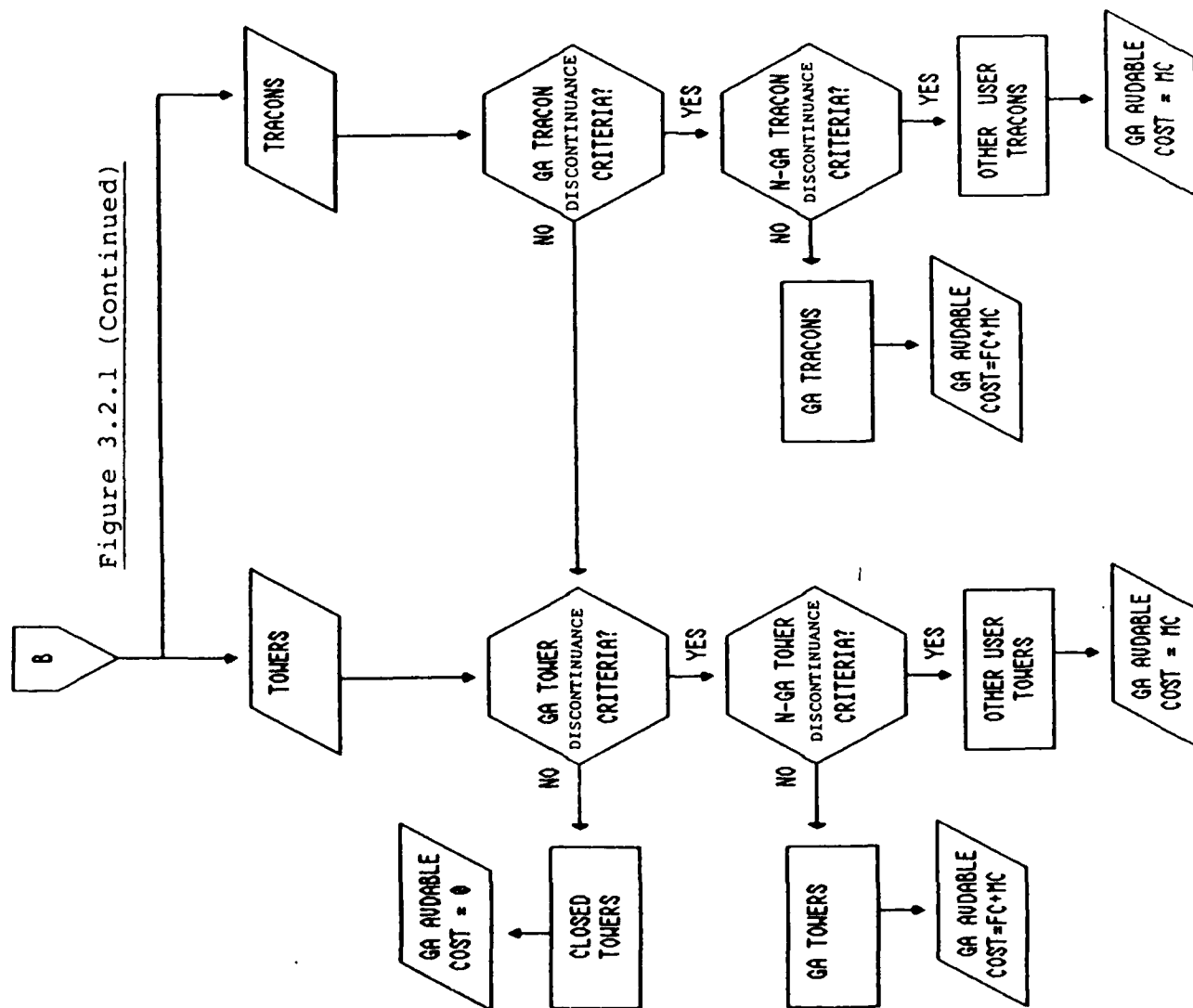


Figure 3.2.1 (Continued)



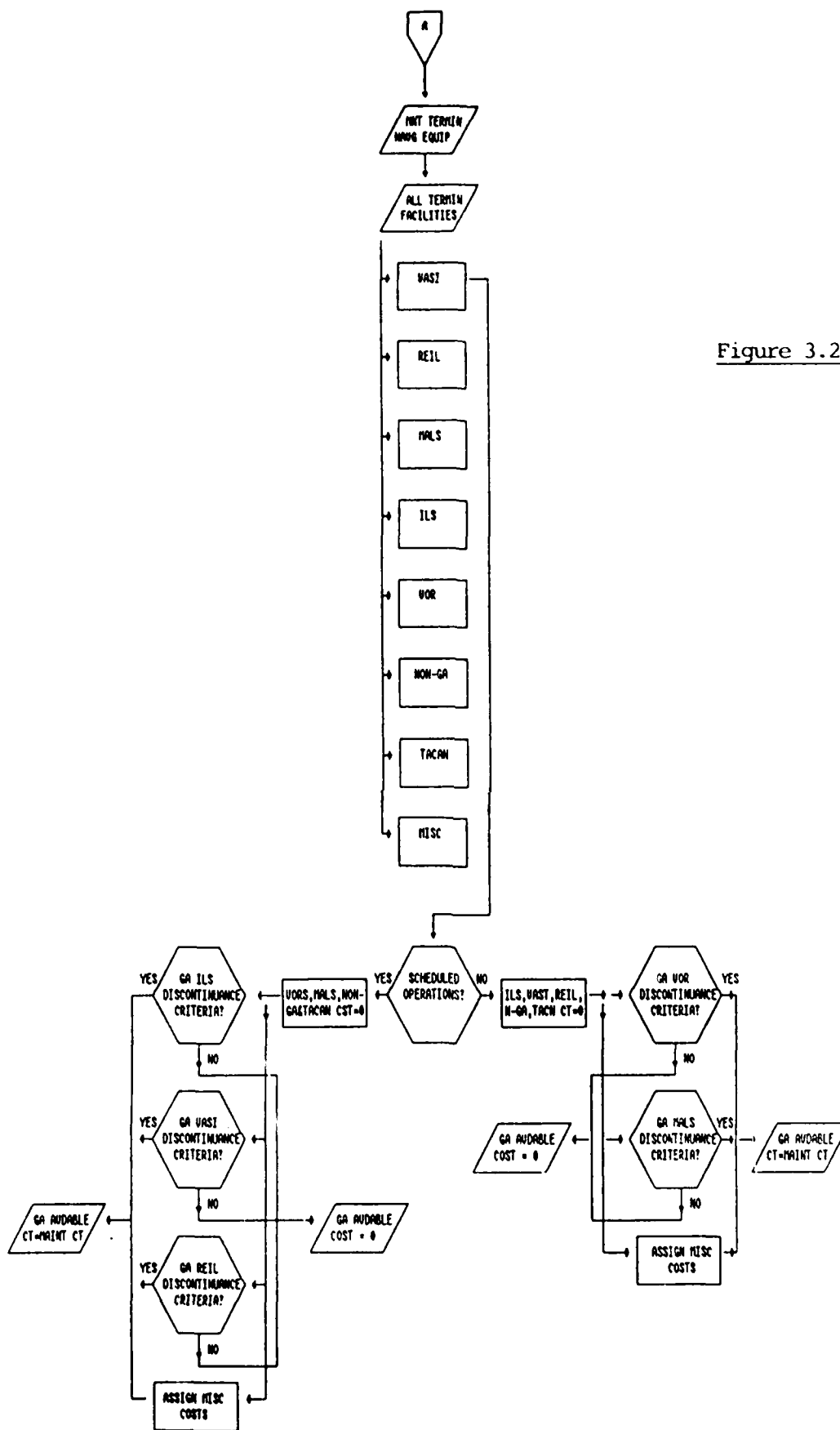


Figure 3.2.1 (Continued)

Table 3.2.1 summarizes the categories and their treatment in the minimum cost allocation scenario. Each of these categories is briefly discussed below.

3.2.1 Overhead

In the minimum general aviation cost allocation, only those overhead items that are attributable solely to general aviation are included. The first type of overhead is the cost of administering commercial service and general aviation grants which are deemed solely to benefit general aviation users. These costs were calculated as a proportion of the cost of administering the total grants awarded to commercial service and general aviation airports.¹⁹

The cost of aviation standards inspection programs could also be avoided in the absence of general aviation. An analysis of the levels of effort associated with inspecting only general aviation aircraft and facilities was performed to identify these costs.²⁰

Any administrative or overhead costs which did not fall into one of the two above categories was classified as a joint cost shared with other users and therefore was excluded from the minimum general aviation allocation. A summary of these overhead items, and all other cost categories in the minimum general aviation system can be found in Table 3.2.2.

It should be noted that the treatment of the cost of aviation standards is a major topic in Volume 3 of this report. Under one of the scenarios presented in that volume, all costs for aviation standards should be borne by the general public. If that argument is accepted, then these costs are excluded from

Table 3.2.1

COST CATEGORIES OF MINIMUM GA ALLOCATION

<u>Category</u>	<u>Description</u>	<u>Treatment *</u>
Overhead	Grant administration and aviation standards.	The administrative costs that could be avoided in the absence of GA.
Capital Projects	Grants, F&E and R&D	The projects which benefit only GA users.
FSS	Direct GA costs and all joint costs of operating FSSs.	Avoidable costs include all GA variable costs plus all joint operating site costs because in absence of GA, FSSs would not exist
ARTCCs	Variable costs of GA handles.	Avoidable costs include only variable costs, but no joint costs because ARTCCs would not exist in the absence of GA.
Terminal Navigation Equipment	The cost of maintaining only those Nav aids which would pass establishment criteria with only GA activity.	Avoidable costs include only maintenance costs of those pieces of equipment required for GA to maintain safety.
Terminal Control Facilities	Variable and joint costs of operating terminal facilities that are required by GA activity but not by other users. Variable cost of facilities required by GA and by other users.	Avoidable costs are those which would disappear in absence of GA.

* In all cases, costs that are joint with non-GA users are allocated to those users, and not to GA.

Table 3.2.2

1985 MINIMUM GA ALLOCATION

MINISYS

13-Aug-86

COST CATEGORY	VARIABLE COST	JOINT COST	AIR TAXI	GA-PISTON	GA-TURBO	ROTORCRAFT	TOTAL COST
OPERATIONS OVERHEAD							
GRANT ADMINISTRATION	\$0	\$5,451,782	\$656,474	\$2,340,556	\$2,163,087	\$283,665	\$5,451,782
AVIATION STANDARDS	\$0	\$27,417,664	\$3,336,680	\$11,421,883	\$11,217,426	\$1,441,755	\$27,417,664
TOTAL OVERHEAD	\$0	\$32,869,445	\$3,993,074	\$13,770,439	\$13,380,513	\$1,725,420	\$32,869,445
CAPITAL PROJECTS							
BENEFITING GR:							
CS GRANTS	\$0	\$6,389,686	\$0	\$719,986	\$5,669,700	\$0	\$6,389,686
GA GRANTS	\$0	\$43,322,836	\$1,879,650	\$49,820,266	\$31,614,120	\$0	\$43,322,836
F&E GA PROJECTS	\$0	\$53,684,795	\$6,714,009	\$23,157,518	\$28,666,975	\$3,146,213	\$53,684,795
R&D GA PROJECTS	\$0	\$5,070,991	\$610,115	\$2,296,950	\$1,878,827	\$285,899	\$5,070,991
TOTAL CAPITAL PROJECTS	\$0	\$149,667,508	\$9,283,855	\$76,002,640	\$68,828,901	\$3,432,112	\$149,667,508
FLIGHT SERVICE STATIONS							
AIR ROUTE TRAFFIC CONTROL CENTERS	\$165,023,283	\$26,359,186	\$15,520,797	\$137,761,197	\$27,051,966	\$10,228,509	\$191,302,469
TERMINAL NAVIGATION FACILITIES	\$116,868,042	\$0	\$11,741,878	\$32,293,525	\$72,532,639	\$0	\$116,868,042
TERMINAL CONTROL FACILITIES:	\$0	\$7,230,889	\$872,062	\$3,168,555	\$2,873,451	\$376,821	\$7,230,889
TOWERS	\$12,882,265	\$12,200,262	\$2,377,281	\$17,021,690	\$3,565,457	\$2,126,179	\$25,090,527
TRACONS	\$56,886,290	\$942,690	\$4,541,286	\$43,620,540	\$5,592,149	\$3,132,306	\$57,796,226
TOTAL MINIMUM GA ALLOCATION	\$351,659,880	\$228,277,900	\$48,250,153	\$323,598,595	\$186,125,075	\$21,821,346	\$579,905,106
FULL GA SHARE OF BUDGET							
--DOLLARS							
			\$131,733,549	\$682,954,321	\$528,163,451	\$63,826,298	\$1,398,677,618
--PERCENTS							
			2.52%	13.04%	9.94%	1.22%	26.71%
MINIMUM GA ALLOCATION AS PERCENT OF BUDGET							
			0.92%	6.18%	3.55%	0.40%	11.00%
FULL GA SHARE OF BUDGET IF REGULATORY COSTS ARE ALLOCATED TO THE PUBLIC							
--DOLLARS							
			\$115,420,350	\$644,163,045	\$485,753,761	\$57,952,009	\$1,303,237,972
--PERCENTS							
			2.20%	12.30%	9.28%	1.11%	24.89%
MINIMUM GA ALLOCATION AS PERCENT OF BUDGET IF REGULATORY COSTS ARE ALLOCATED TO THE PUBLIC							
			0.86%	5.96%	3.34%	0.37%	10.55%

the minimum general aviation allocation, with the result that overhead costs are reduced. This scenario is reflected in the results at the bottom of Table 3.2.2.

3.2.2 Capital Projects Which Benefit Only General Aviation

Capital projects were divided into three categories: facilities and equipment, research and development, and airport grants. The FY1985 FAA budget was examined in order to determine which projects in each category would not be undertaken in the absence of general aviation. The amounts for each category are shown in Table 3.2.2, along with the total value of capital projects allocated to the minimum GA system.

3.2.3 Flight Service Stations

The primary purpose of flight service stations (FSSs) is to serve general aviation. Therefore, the joint costs of the FSS system (excluding the share allocated to government users), were assigned to the minimum GA system. Also, the variable costs associated with general aviation use of FSSs is properly allocated to the minimum GA allocation. The results are presented in Table 3.2.2.

3.2.4 Air Route Traffic Control Centers

The allocation of a portion of the cost of Air Route Traffic Control Centers (ARTCCs) to the minimum GA system is based on three conclusions about the nature of ARTCCs.

- 1) ARTCCs must be considered as a system. The value of providing en route radar separation above a minimum altitude is lost if there are gaps in the coverage.
- 2) The number of facilities and the technology in use at those facilities would not be substantially different

if general aviation did not exist. The need for radar separation of commercial traffic would continue, although the total level of traffic handled by ARTCCs would be reduced by the number of general aviation operations which they now perform.

- 3) General aviation aircraft cannot meet current safety criteria for high altitude operation without making use of radar separation.

Based on these conclusions, only the marginal cost per general aviation handle by the ARTCC system, as estimated in the econometric analysis, is allocated to the minimum GA system. The results are shown in Table 3.2.2.

3.2.5 Terminal Navigation Equipment²¹

Maintenance costs were the focus of the analysis of terminal navigation equipment in the minimum GA system. Installation costs were assumed to be sunk, and replacement costs were excluded.²² The goal of the analysis was to identify specific pieces of equipment at specific sites which met FAA establishment criteria based solely on general aviation traffic and to assign the cost of maintaining that equipment to the minimum GA system.

The first step of the analysis as seen in the fifth branch of the flowchart in Figure 3.2.1, was to separate the terminal navigation equipment (listed in Facilities Master File--System 3: Terminal Navigation Facilities [FMF-System-3]), into eight categories. These categories were:

- o approach lighting systems (e.g., VASI),
- o runway end identifier lights (e.g., REIL),

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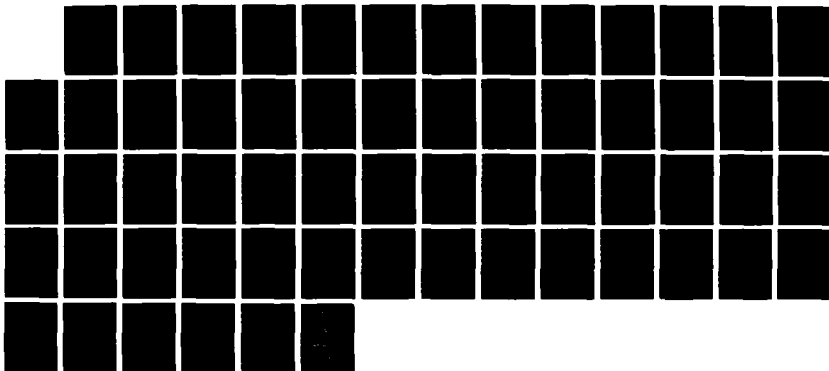
ALLOCATION OF FEDERAL AIRPORT AND AIRWAY COSTS FOR FY
1985(U) FEDERAL AVIATION ADMINISTRATION WASHINGTON DC
OFFICE OF AVIATION POLICY AND PLANS D E TAYLOR ET AL.
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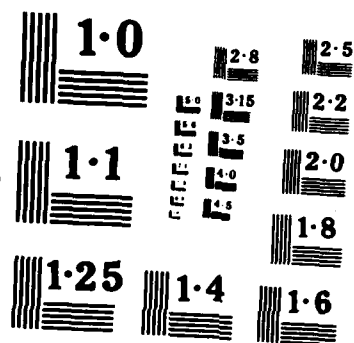
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- o medium-intensity approach lighting systems (e.g., MALS, MALSR),
- o instrument landing systems (e.g., GS, LOC),
- o radio beacons/directional aids (e.g., VOR, LDA),
- o various air-carrier related equipment (e.g., LLWAS),
- o military equipment (e.g., TACAN and TACR), and
- o miscellaneous equipment (e.g., PCS, RMCF).

The air-carrier and military equipment were excluded from further consideration, by definition.

Once the equipment categories had been established, each piece in the first five categories was subjected to a two-step establishment test based on traffic statistics. (The miscellaneous equipment was allocated differently, since no establishment criteria exist for it.) In the first part of the test, the establishment ratio, as found in the Airway Planning Standard Number One--Terminal Air Navigation Facilities and Air Traffic Control Services, was calculated twice; as follows:

- 1) based on GA traffic alone, and
- 2) based on all traffic except general aviation.

The second step in the test was to determine to which of the three categories shown in Table 3.2.5.1 the given piece of equipment belonged. Thus, for example, if the establishment ratio for a MALS at a particular airport were 1.2 based only on general aviation traffic, and 1.4 based only on air carrier traffic, it would be placed in category 2.²³

Only those pieces of equipment which belonged to category 3 were assigned to the minimum GA system. Equipment in category 1 would not be needed for the safe operation of an air system which

Table 3.2.5.1

ALLOCATION OF TERMINAL NAVIGATION EQUIPMENT COSTS
TO MINIMUM GENERAL AVIATION SYSTEM

<u>Establishment</u> <u>Criteria Tests</u>		<u>Result</u>
<u>GA Traffic</u>	<u>Non-GA Traffic</u>	
Category 1:		
<1	--	Excluded from minimum GA system
Category 2:		
>1	>1	Excluded from minimum GA system
Category 3:		
>1	<1	Maintenance costs allocated to minimum GA system

only served general aviation, while equipment in category 2 would be required for safety even if general aviation did not exist. At this point, equipment in the miscellaneous category was allocated on a site-by-site basis in such a way that the share of miscellaneous terminal navigation costs borne by the minimum GA system at each site was the same as the share of the other equipment assigned to the minimum system.

Based on staffing data contained in the FMF-System 3, total person-years required for maintaining the terminal navigation equipment allocated to the minimum GA system were found to be 106.01. This number was multiplied by the fully-burdened annual labor cost of \$61,094.40 per employee-year for airway facility labor.²⁴ The results, after an allocation for government use was excluded, are shown in Table 3.2.2.

3.2.6 Terminal Control Facilities

Two types of terminal control facilities were considered for inclusion in the minimum GA system: Air Traffic Control towers (towers) and Terminal Remote Approach Control Facilities (TRACONS). An analysis similar to that performed for terminal navigation equipment was used for these facilities, with the same goal--to identify those facilities which are required for safety based only on general aviation traffic. The analysis was modified, however, to take into account the possibility that even though a TRACON might not be justified at a particular site, a tower might be justified instead.

The specific method followed was to subject each existing tower and TRACON to FAA establishment criteria twice, once based on only general aviation traffic, and once based on all traffic

except general aviation. The facilities again fell into three categories depending on the outcome of these tests, where an establishment ratio of at least one was required for a facility to pass.

- o A TRACON which failed establishment criteria based on GA traffic was retested using tower establishment criteria, regardless of the outcome of the test based on non-GA traffic. An air traffic control system with only general aviation traffic could operate safely without this TRACON, although it might require a tower at the same site.
- o If a TRACON passed the test based on both GA and non-GA traffic, then only the variable costs of GA allocation traffic at this facility was allocated to the minimum GA allocation. Safe operation of the air traffic system would require this TRACON even if general aviation did not exist.
- o If a TRACON passed the test based on GA traffic but failed based on non-GA traffic, the joint cost of the facility as well as the variable cost of GA traffic at the facility was allocated to the minimum system. If only general aviation traffic were to exist, such a TRACON would be required for safe operation of the air traffic system, but it would not be required if all traffic except general aviation were to exist.

The analysis for towers followed analogous reasoning except that costs of facilities which failed the GA-traffic-only test

were excluded entirely from the minimum GA allocation. The total cost for TRACON's and towers allocated to the minimum GA system is summarized in Table 3.2.2.

3.3 Comparison of Minimum GA System Allocation to GA Share of Full-Cost Allocation

If regulatory costs are allocated to users, the components of the FY1985 minimum general aviation allocation sum to a total of \$579.9 million (or 11.1% of the total GA budget). The sum is \$552.4 million (or 10.8% of the budget) if regulatory costs are allocated to the Public Interest. Both allocations are substantially less than the GA share of the full cost allocation, which ranges between 26.7% when users are allocated regulatory costs and 24.9% when they are not. The major reason for the difference is the exclusion of all joint costs from the minimum system allocation.

Table 3.2.2 also shows the allocation of the minimum GA system costs among the four GA user groups. Costs which are joint among the users were allocated based on activity, marginal costs and relative demand elasticities.

There are several issues which must be kept in mind when making a comparison between the full cost and minimum GA system allocations. All of these issues are related to the omission of joint costs from the minimum system. The most important point to understand is that joint costs are inherently difficult to allocate in such a manner that all user groups will be satisfied. If a minimum system allocation were constructed for each user group, taxes based on the combination of these allocations would

be insufficient to cover the costs of the FAA because joint costs would not be paid by any group.²⁵

It must also be noted that the minimum GA system presented above is not sustainable. This is true primarily because it relies on jointly-used facilities, such as ARTCCs and certain towers and TRACONS, for which no capital expenditures are allocated. Once these facilities wear out, there would be no way to replace them within the limits of the minimum GA allocation.²⁶

Finally, it is possible that the FAA exhibits economies of both scale and scope in its provision of services and that some of the costs of the minimum GA allocations are underestimated. This may be true because the costs of the current system reflect the advantages of large scale.²⁷ A small scale stand-alone GA operation would not exhibit these advantages.

NOTES

¹This solution applies when the cross elasticities of demand among the goods subject to the budget constraint are zero. When one takes into account the cross effects, the solution is more complicated but retains the same pricing tendency. Technically, only relative price elasticities are required in the Ramsey Pricing formulation and these relative elasticities should reflect cross effects. Therefore, the simpler solution is used in this study.

²It would be desirable to estimate long-run marginal costs using econometric techniques, at least at the operating site level. However, such equations could not be developed for this study because the FAA does not maintain records of the original cost of equipment placed at specific sites. In the present study, the maintenance of those assets is included in the marginal cost estimates developed at the site level, but the cost of capital and depreciation are not.

³An estimate was developed of the expected number of units of service consumed by each user group per flight. The estimated costs for these expected services was estimated based upon the econometric cost functions developed for the operating sites. The cost category would then be allocated as a markup above these expected marginal costs. Details of these allocations are presented in the sections which immediately follow.

⁴An alternative view is that while the surrounding communities benefit from a low activity tower, aviators using the facility also benefit. Therefore, aviators should pay for those costs they impose up to the level of the benefits they receive; the remaining costs should be borne by the public sector. One difficulty with this view is that only a few aviators would benefit from the tower, while all aviators as a group would be allocated the cost. Unlike the case of towers which meet the benefit-cost test and therefore are needed for safety reasons, users in general would probably be unwilling to pay for a facility that is not needed.

⁵The equation used to develop the marginal cost estimates utilized in this Ramsey algorithm are as follows:

let $VC_{ij} = q_{ij} \times MC_{ij}$, where

q_{ij} = user group j's activity at operating site i

MC_{ij} = user group j's marginal cost at operating site i

VC_{ij} = variable cost of user group j at operating site i.
For each user group j, sum VC_{ij} over the four types of operating

sites:

$VC_j = (q_{ij} \times MC_{ij})$, where

VC_j = total variable costs at all operating sites attributable to user group J.

Then define Q_j as the total operations by user group j at FAA towers and TRACONS. Expected system-wide marginal costs per operation by j at a tower or TRACON as:

$$\overline{MC_j} = \frac{VC_j}{Q_j}$$

These marginal costs are used in the Ramsey Pricing algorithm to allocate costs in other major cost categories.

⁶Air taxi operators provide unscheduled, for-hire services. They are included in the GA user category in this study. Before airline deregulation, air taxis included scheduled commuter operations. Therefore, in the 1978 cost allocation study, some scheduled operations were included in the GA user category. Since deregulation, there has been substantial growth in the commuter industry. Because of this growth, it became important to segregate explicitly air taxi and commuter operations in the present study.

⁷R. Fain and D. Garvett. "Airport and Airway System Cost Allocations." (DOT-FA69NS-162) p. 3-9.

⁸The 1978 results were adjusted for increases in FAA pay for the period 1977-1984. this method of indexing for inflation is appropriate since most of the costs included in both studies are labor costs. FAA pay increased 61 percent in the period; as a reference, the Producers Price Index increased by 63 percent in the same period.

⁹Department of Transportation, Federal Aviation Administration: "Flight Service Station Privatization Evaluation Report" (June, 1985).

¹⁰FASB, Statement No. 2. Professional Standards-Accounting, sec. 4211.12.

¹¹There are three types of projects eligible for airport grants:

- o Airport Planning: grants made to local officials or authorities to examine aviation needs either at a particular airport or area-wide. The resulting information assists officials in making decisions about future development of airports and is also employed by the FAA in developing NPIAS.

- o Airport Development: eligible projects include facilities or equipment associated with the construction, improvement, or repair (excluding routine maintenance) of an airport. Included are such items as land acquisition, site preparation, repair of runways, and the purchase of safety equipment required for certification of the facility. Excluded are construction of hangars, parking areas for automobiles, or buildings not related to the safety of persons on the airport.
- o Noise Compatibility Programs: eligible projects are governed by Part 150 of the Federal Aviation Regulations and include direct grants to either the airport or the surrounding area to reduce the impacts of airport-related noise on the local community.

¹²The 1982 Act also prescribes general criteria for the distribution of funds:

- o Not more than 50 percent of total grant monies can be apportioned to primary airports.
- o \$12.5 million must be apportioned for Alaskan airports.
- o 12 percent must be apportioned for state and insular areas under an area/population formula.
- o The remaining monies are discretionary but must satisfy the following criteria: ten percent must be for reliever airports; eight percent for noise compatibility projects; 5.5 percent for commercial service airports; and one percent for integrated system plans.

¹³OAG data were used to identify commuter and airline flight activity at primary airports.

¹⁴Data on 1981 were unavailable.

¹⁵A large grant was defined as being in the top half of grants for an airport type when ranked from highest to lowest dollar amount. The remainder were small grants.

¹⁶OAG data were used to identify the degree that each air carrier group used these facilities.

¹⁷It should be noted that in the minimum general aviation system allocation discussed in Section 3.0, reliever grants are not assigned to general aviation. This allocation recognizes that reliever airports receive grants primarily to encourage general aviation use of reliever instead of primary and commercial service airports. The congestion costs at primary airports in the absence of relievers would be shared by both air carrier and general aviation users. Under the GA-minimum system,

general aviation shares no joint cost responsibility, and so the congestion costs avoided by reliever airport grants are assigned to other users. Under the full cost allocation, users are assigned costs for the services they receive. These costs are identified by the avoidable cost of the grant as identified in the justification statements.

¹⁸A.N. Sinha, Minimum General Aviation Airport and Airway System Requirements, (McLean, VA, The MITRE Corporation, METREK Division, September, 1977).

¹⁹Grants to primary and reliever airports were excluded from the minimum GA system. Grants to primary airports are based entirely on air carrier enplanements. Reliever airports decrease congestion at primary airports. Since this congestion is caused by both air carrier and general aviation traffic, the cost of relieving it is a joint cost, and is therefore excluded.

²⁰The data were insufficient to identify all GA-related programs. In particular, no aircraft certification costs could be attributed to GA.

²¹The analyses in Section 3.2.5 and 3.2.6 were limited by the available data. Specifically, operations by GA user groups were not available on a site-by-site basis. Thus, government operations were included in the facility establishment analyses in these sections.

²²It should be noted that terminal navigation replacement costs solely for GA could not be separately identified as capital projects. Therefore, they are not part of the GA-only capital projects category either.

²³In order to break up the database into manageable portions, LOCIDs with scheduled service were treated separately from those without scheduled service. This procedure, which is reflected at point A in the flowchart in Figure 3.2.1, did not affect the assignment process described in the text.

²⁴Airway facility labor per employee was derived by adding an additional 47 percent to the initial fully burdened salary of \$41,560.80 because of management, supervision, engineering and other factors not directly found in the FMF. This salary represents an average for GS-11 and GS-12 Step 5 employees, which is appropriate for airway facility technicians.

²⁵If the system is to operate without a subsidy from general revenues, joint costs must be covered. It is inequitable for one group to avoid paying a share of these costs, as general aviation would do if taxes were based on the minimum GA system allocation. The Ramsey Pricing method for allocating joint costs, on which the full cost allocation rests, is widely accepted by economists as the best method of handling this inherently difficult problem because it minimizes the economic distortions caused by user taxes.

²⁶In addition, replacement expenditures for terminal navigation equipment were not available on a per-site basis and, therefore, were excluded from the analysis. The system is also ungovernable, because it omits virtually all administrative costs, since most of them are joint costs.

²⁷Economies of scale exist when the producer of some good or service is able to lower the average cost of producing a particular unit of output merely by producing at a larger scale. Economies of scope, on the other hand, exist when the fact that a firm produces two or more different goods makes the average costs of all the goods less than they would be if the goods were produced separately. While it is beyond the scope of the present study to investigate whether either type of economy is present in the FAA, the agency is certainly a likely candidate for both types, since it is a large scale producer of more than one service. To the extent that economies of either scale or scope do exist in the current FAA system, they are reflected in the estimates of the marginal cost of general aviation use of the various facilities in the system. A true stand-alone minimum GA system would provide fewer services at a smaller scale of operation. Therefore, econometric estimates based on the current system would underestimate the cost of such a minimum system.

GLOSSARY OF ECONOMICS TERMS

Administrative Efficiency:

For a tax to be administratively efficient, the administration of the tax should impose the lowest possible costs, i.e., taxes should be easily verifiable and enforceable, simple to pay, and easy to understand. Levying any tax imposes two types of administrative costs. Those borne by the agency collecting the tax and those borne by the groups or individuals that pay the tax. An administratively efficient set of taxes will minimize both types of costs while still collecting the required revenue.

Avoidable Costs:

Costs that would be avoided by the FAA if a user group discontinued its use of all or part of the FAA airport and airway system. Included in avoidable costs are both variable and other costs attributable to a user group's consumption of FAA services. Avoidable cost is the closest practical measure of long-run marginal cost and is the key cost concept utilized in this study.

Cross-Price Elasticity:

A measure of the responsiveness of quantity demanded to a change in the price of another good. It is defined as the percentage change in quantity divided by the percentage change in some other good's price.

Direct Taxes:

Taxes that vary directly with the services provided. An example is a fee paid each time an aircraft owner makes a landing. One objective of a direct user tax is to promote economic efficiency; i.e., users pay only the costs of producing the services they actually consume.

Econometrics:

The study of interrelationships between variables. Econometric cost functions can be used to evaluate the marginal cost of the use of certain services. Regression analysis is an integral part of econometrics.

Economic Efficiency:

For a tax to be economically efficient, the tax charged should closely correspond to the cost of providing the services; i.e., users pay for the costs they impose.

Economic Rent:

That part of the payment to a factor in excess of the amount that is necessary to keep the factor from transferring to another use. It is a surplus payment.

Economies of Scale:

Decreasing long-run average cost as output increases and the firm moves along an expansion path. The producer of some good or service is able to lower the average cost of producing a particular unit of output merely by producing at a larger scale.

Economies of Scope:

Decreasing long-run average cost as the line of services expands. When a firm produces two or more different services, the average costs of all the services are less than they would be if the services were produced separately.

Elasticity of Demand:

The price elasticity of demand is defined as the percentage change in quantity divided by the percentage change in price: $\% \Delta Q / \% \Delta P$. If this ratio is greater than one, then the good is considered to be elastic; i.e., quantity demanded is very responsive to changes in price. For example, if the price of an elastic good increases by 1 percent, the quantity demanded will decrease by more than 1 percent. Total Revenue, defined as $P \cdot Q$, thus will decline.

On the other hand, if the ratio is less than one, then the good is inelastic; i.e., it is not very sensitive to changes in price. For example, if the price of an inelastic good increases by 1 percent, the quantity demanded will decrease but by less than 1 percent. Total Revenue thus will increase. An example of an inelastic good is cigarettes. Cigarettes are not very responsive to price changes because even if prices rise smokers will continue to buy them.

Following this line of reasoning, a firm that must increase prices to cover costs would logically raise the prices of its inelastic goods instead of its elastic goods. This concept forms the basis for Ramsey Pricing.

Externality:

Effects, either good or bad, on parties not directly involved in the production or use of a commodity. A negative externality occurs when an action taken by an economic unit results in uncompensated costs to others. For example, an aircraft may pollute the air with smoke. Such actions result in costs to the surrounding community. However, the market price (or tax) paid by the aircraft owner does not reflect the full social costs since it does not include a charge for the air pollution created.

Fixed Costs:

Costs that do not change with output.

Income Elasticity:

A measure of the responsiveness of quantity demanded to a change in income. It is defined as the percentage change in quantity divided by the percentage change in income, holding prices constant.

Indirect Taxes:

Taxes that are levied on groups of services consumed by user groups, instead of per unit of service. An example is a tax levied on airline revenues that covers

all airline users of the FAA system regardless of services actually consumed by each airline individually.

Joint Costs:

All fixed costs and all those costs not avoidable by any single user group, but avoidable by some or all users together; i.e., they are all costs which do not vary with the level of operations of a particular user at a particular facility.

Long-Run Marginal Cost:

The change in long-run total cost in response to a change in output. The long-run marginal cost of the use of the airport and airway system is the additional long-run cost incurred by the FAA due to one additional unit of service produced. When prices are set at long-run marginal costs--the ideal situation--users consume only those services whose resources cost they are willing to pay for. However, some services, such as the results of an R&D program, cannot be easily allocated among user groups. Thus, the ideal cannot always be reached.

Market Distortions:

These occur when prices are established at levels above long-run marginal costs. In such a situation, some users willing to pay the resource costs of production for the use of a service are precluded from doing so because the price (tax) has risen. This market

distortion (prices set above marginal costs) results in a loss in net benefits. This loss can be minimized by Ramsey Pricing.

Pure Private Good:

The consumption of such a good involves reduction of the available supply of the good and the exclusion of other consumers from consumption. An example is aviation fuel.

Pure Public Good:

A good which is both nonexhaustible and nonexcludable in consumption. All users can share in the consumption of such a good without diminishing its supply. No one can be excluded from consuming it. National defense is an example of a pure public good.

Ramsey Pricing:

Used to allocate joint costs among user groups. If joint costs were not allocated, the prices (taxes) would not be sufficient to cover FAA costs. Yet the allocation of joint costs among users leads away from the ideal state where price equals long-run marginal cost and towards the case where price exceeds marginal cost. In such a case some users are precluded from using some services. To minimize this loss in net benefits (which cannot be completely eliminated as long as price exceeds marginal cost), Ramsey Pricing is utilized. Ramsey Pricing is based on the concept of elasticity. Inelastic users are less sensitive to price changes and therefore are less likely to reduce

their consumption of services even if prices (taxes) do rise. By charging higher prices to inelastic users, the loss in net benefits is minimized.

Substitution Elasticity:

This measures the rate at which a consumer would substitute one good for another when the price of the original good changes, under the assumption that the consumer's utility is held constant.

Variable Costs:

Costs that vary directly with changes in output. In this study, variable costs are defined as the product of the estimated marginal costs multiplied by the estimated activity by each group.

Variance:

The expected value of the squared deviations of a random variable from its expected value. Variance is a measure of dispersion. R^2 is a measurement used to determine what percentage of the variance in a data set is explained. Thus a high R^2 is desirable.

GLOSSARY OF FAA TERMS

AC-D:

Domestic Air Carriers

AC-F:

Freight Air Carriers

AC-I:

International Air Carriers

AIP:

Airport Improvement Program. The AIP makes grants to primary, reliever, commercial service, and general aviation airports. This program is governed by the Airport and Airway Improvement Act of 1982.

Airlines:

This user group includes domestic air carriers, international air carriers, freight air carriers, and commuter air carriers.

Airport Grants:

Grants made to operators of primary, commercial service, reliever and general aviation airports. One of six major cost centers in the FAA budget.

Air Taxi:

An air carrier authorized to provide, on demand, public transportation of persons and property by aircraft. Usually it is a small aircraft "for hire" for a specific trip.

ARTCC:

Air Route Traffic Control Center. An FAA facility to provide air traffic control service to aircraft operating on IFR flight plans within controlled airspace and principally during the en route phase of flight. Domestic air carriers and the military constitute the largest shares of ARTCC costs. The main output of ARTCCs is the separation of aircraft in controlled airspace between terminal areas. Output is measured by handles.

AT:

Air Taxis

ATC:

Air Traffic Control. A service operated by appropriate authority to promote the safe, orderly, and expeditious flow of air traffic.

ATCT:

Airport Traffic Control Tower. Provides services for aircraft operating on the movement area and in the vicinity of an airport.

AWOS:

Automatic Weather Observation System, an FAA unmanned weather observation device.

COM:

Commuters

Cost Centers:

The FAA budget can be separated into six identifiable cost centers: operating site costs, F&E, R&D, airport grants, NAVAID maintenance and regulatory costs, and overhead.

FAA:

Federal Aviation Administration. The FAA is the single producer of organized and safe airspace in the United States. Some of the responsibilities of the FAA are enforcement of safety regulations, aviation research and development, and the administration of the Federal Air Traffic Control System.

F&E:

Capital expenditures made by the FAA to replace or improve facilities or equipment. One of six major cost centers in the FAA budget.

Flight Plan:

Specified information relating to the intended flight of an aircraft that is filed orally or in writing with a flight service station or an air traffic control facility.

FSS:

Flight Service Station. Facilities operated by the FAA as part of the National Airspace System. In general, they offer preflight and in-flight services to general aviation and to a lesser extent to other sectors of aviation. The four major FSS services are IFR flight plans, VFR flight plans, pilot briefs and air contacts.

Full Cost Allocation:

Each user group is assigned two components of costs for each cost center--avoidable costs and a share of joint costs.

GA-P:

General Aviation Piston Aircraft

GA-T:

General Aviation Turboprop and Turbojet Aircraft

General Aviation:

This user group includes air taxis, operators of general aviation piston aircraft, operators of general aviation turboprop and turbojet aircraft, and operators of rotorcraft.

Handles:

Unit of measurement for ARTCC output, defined as two times ARTCC departures plus overs.

IFR:

Instrument Flight Rules. A body of FAA rules governing the procedures for conducting instrument flights. The rules may refer to meteorological conditions, pilot qualifications, or air traffic control services. IFR is also a term used by pilots and controllers to indicate type of flight plan.

IFR Overs:

An IFR flight that originates outside the ARTCC area and passes through the area without landing.

LLWAS:

Low level windshear alert system. Air-carrier equipment.

MALS:

Medium-intensity approach lighting system.

MALSR:

Medium-intensity approach lighting system with runway alignment indicator lights.

Minimum General Aviation Cost Allocation:

This represents the minimum costs that general aviation could incur consistent with current safety criteria. No costs shared jointly with other users are assigned to the minimum general aviation system.

NARACS:

National Radio Communications Systems.

NAVAID:

Navigational aid. Any visual or electronic device airborne or on the surface which provides point to point guidance information or position data to aircraft in flight.

NAVAID Maintenance and Regulatory Costs:

Costs incurred by the FAA in maintaining navigation and other equipment not located at operating sites and in regulating aircraft operations and manufacturing, and airports. One of six major cost centers in the FAA budget.

NOAA:

National Oceanic and Atmospheric Administration, an agency of the Department of Commerce, charged with tasks such as keeping track of and forecasting weather.

NPIAS:

National Plan of Integrated Airport Systems.

NWS:

National Weather Service, part of NOAA.

Operating Site Costs:

Labor, maintenance, and leased communications costs at ARTCCs, FSS, Towers, and TRACONS. Operating sites as a group produce the major final product of the FAA-organized and safe airspace. These costs are one of six major cost centers in the FAA budget.

Overhead:

Costs of headquarters and regional administration, and procurement. One of six major cost centers in the FAA budget.

Pilot Briefing:

A service provided by the Flight Service Station to assist pilots in flight planning. Briefing items may include weather information, military activities, flow control information, and other items as requested.

Public Interest Expenditures:

Cost center resources expended to produce public goods, redress externalities, or benefit non-aviators.

Public Sector:

This user group includes military and civil government users, and public interest expenditures.

R&D:

Expenditures made by the FAA on research and development programs consistent with its mandate to build and maintain an efficient and safe airport and airways system. One of six major cost centers in the FAA budget.

REIL:

Runway-end identification lights. Two synchronized flashing lights, one on each side of the runway threshold, which provide rapid and positive identification of the approach end of a particular runway.

SUA:

Special Use Airspace. Airspace of defined dimensions identified by an area on the surface of the earth wherein activities must be confined because of their nature and/or wherein limitations may be imposed upon aircraft operations that are not a part of those activities.

TACAN:

Tactical air navigation. Military equipment.

Towers:

They produce landing and take-off clearance services in the terminal area.

TRACON:

Terminal Radar Approach Control. TRACONs produce three identifiable services: radar approach control services at the principal airport; approach control services at secondary airports guided by the TRACON radar; and radar service for flights made over the terminal area controlled by the TRACON.

Turbojet Aircraft:

An aircraft having a jet engine in which the energy of the jet operates a turbine which in turn operates the air compressor.

Turboprop Aircraft:

An aircraft having a jet engine in which the energy of the jet operates a turbine which drives the propeller.

User Groups:

The users of the FAA Airport and Airway Systems can be grouped into three general categories: airlines, general aviation, and the public sector.

VASI:

Visual Approach Slope Indicator. An airport lighting facility providing vertical visual approach preventing collision between known aircraft, for an aircraft to proceed under specified traffic conditions within controlled airspace.

VFR:

Visual Flight Rules. Rules that govern the procedures for conducting flight under visual conditions. The term 'VFR' is also used in the United States to

indicate weather conditions that are equal to or greater than minimum VFR requirements. In addition, it is used by pilots and controllers to indicate type of flight plan.

VOR:

VHF omnidirectional range. A directional aid.

APPENDIX A

RAMSEY PRICING

Section A.1 Introduction

The cost allocation analysis of this study relies on the method of Ramsey Pricing. This appendix explains the reasons for incorporating this method into the analysis. It also provides some technical background on Ramsey Pricing.

The nature of the services which the FAA provides is such that a significant portion of its costs can be classified as joint costs. For the purposes of this study, joint costs are defined as all costs which do not vary with the level of operations of a particular user at a particular facility. These costs fall into two categories:

- 1) All fixed costs.
- 2) Avoidable costs which are jointly attributable to a subset containing more than one type of user.

Administrative overheads found in the operations budget are good examples of fixed costs. An example of a jointly attributable avoidable cost is an F&E project undertaken on behalf of all general aviation user groups.

In terms of economic efficiency, the best way to design user charges for the FAA would be to set them equal to marginal costs. However, the presence of joint costs makes this infeasible for two reasons:

- 1) Marginal costs are not well defined for some services (such as administrative services), and
- 2) The revenue collected by marginal-cost-based taxes would be insufficient to cover the total costs of FAA operations.

These difficulties are commonly found in designing user taxes to support public agencies.

In the place of marginal-cost pricing, the "second-best" approach suggested by economists is Ramsey Pricing. Taxes based on Ramsey Pricing meet two criteria:

- 1) They provide revenue sufficient to cover the total costs of an agency's operations,
- 2) They minimize the distortions caused by the departure from the efficiency principle that the prices (user taxes) should equal marginal costs.

The Ramsey markup above marginal cost for users depends on relative elasticities of demand. The higher the elasticity of demand exhibited by a user group relative to other groups, the lower will be its markup above marginal costs. Similarly, the lower the relative elasticity is, the higher will be the markup above marginal costs. Therefore, those users who exhibit the greatest willingness to pay for the service in question--those with relatively low sensitivity to price--pay more than users who are less willing to pay for the service--those exhibiting relatively high sensitivity to price.

Another way to interpret the Ramsey result is as follows. An optimal departure from marginal cost pricing should minimize the losses in user welfare. This occurs when the marginal loss

in consumer benefits per extra dollar contributed to cover joint costs is equal for all users. If the marginal costs of obtaining an extra dollar of contribution to joint costs from any of the FAA users are not the same, then the social loss could be reduced by giving back the contribution where the loss is high and making it up where a loss is lower. One would continue to reorder the contributions to joint cost made by users until the losses in consumer welfare were minimized.

The remainder of this appendix is divided into two parts. In Section A.2, theoretical and empirical support are provided for the assumption about relative elasticities which was used in the cost allocation model. Section A.3 provides a technical derivation of the Ramsey Pricing formula.

Section A.2 Selection of Elasticities for Use in the Ramsey Pricing Model

In order to use the Ramsey Pricing method to allocate the joint costs of the FAA, it is necessary to know the relative sizes of the demand elasticities for the various user groups. This section gives a theoretical argument as to why GA-piston operators are likely to have relatively high demand elasticities, and provides empirical support for that argument.

A.2.1 Defining the Income and Substitution Effects

One of the fundamental results of microeconomic theory is that the substitution and income effects of a change in the price of a commodity can be analyzed separately. The Slutsky equation defines the substitution and income effects as follows:

$$\frac{\partial Q_1}{\partial p_1} = \left(\frac{\partial Q_1}{\partial p_1} \right) \bigg|_{\Delta u = 0} - Q_1 \left(\frac{\partial Q_1}{\partial y} \right) \bigg|_{\Delta P = 0}$$

This equation represents the change in the quantity demanded of a good or service (Q_1) due to a change in its price. The first term on the right-hand side is the substitution effect. This is the rate at which a consumer would substitute Q_1 for other commodities when the price of Q_1 changes relative to the prices of those other commodities, under the assumption that the consumer's utility is held constant. The second term on the right-hand side of the equation is the income effect. It shows how the consumer would change his demand for Q_1 if his income changed, but relative prices remained the same. The sum of the two effects gives the consumer's reaction to a change in the price of Q_1 .

For example, suppose Q_1 is air transportation from A to B. If the price increases, a consumer may reduce the quantity demanded (Q_1) because: (1) Q_1 has become relatively more expensive or (2) the rise in price has effectively reduced his/her income.

The Slutsky equation can be rewritten in terms of elasticities by multiplying both sides of the equation by P_1/Q_1 , and the right side by y/y , where y represents income. The result is:

$$E_p = E_s - \frac{P_1 Q_1}{y} E_I,$$

where E_p = price elasticity of demand

E_s = substitution elasticity

E_I = income elasticity

P_1Q_1 = ratio of purchases of Q_1 to total household income.

(E_p and E_s are negative numbers; E_I and $\frac{P_1Q_1}{Y}$ are positive for normal goods).

In this form, the Slutsky equation shows the elasticity of demand with respect to price as a function of income elasticity, the proportion of income spent on Q_1 , and the elasticity of substitution.

A.2.2 Why Demand Elasticity for GA-Piston Users is Likely to Exceed That of Other Users

The rewritten Slutsky equation above implies that if the income elasticity and the proportion of income spent on a particular good are relatively high, then the demand elasticity for that good should be relatively high. It is reasonable to expect that both of these factors should be large for GA-piston operators relative to other user groups, all other things being the same. Specifically:

- 1) The ratio of air travel expenses to total income should be higher for GA-piston operators than for other groups.
- 2) The income elasticity of GA-piston operators should be higher than the income elasticity for airline travelers.

As a result, assuming equal substitution elasticities, the elasticity of demand for GA-piston operators should exceed that displayed by other user groups.

GA-piston operators are more likely to devote a substantial portion of their personal income to the production and consumption of air transportation than either airline or other general aviation users. This can be illustrated intuitively by first comparing GA-piston operators with other general aviation groups and then to airline passengers. (More precise empirical evidence will be presented in Section A.2.3).

Relative to other general aviation groups, more GA-piston users operate their aircraft primarily for personal use, rather than for business or other revenue producing reasons. In the latest "General Aviation Activity and Avionics Survey,"¹ over 93 percent of the total general aviation personal hours produced were accounted for by general aviation piston operators. In addition, the latest "General Aviation Pilot and Activity Survey" indicates that 77 percent of all GA-piston aircraft are either owned by individuals or a flying club. As a result, it is more likely that general aviation piston operators must defray the costs of their aircraft out of personal funds, rather than deducting these costs as business expenses.

Relative to airline travelers, GA-piston operators are more likely to devote a substantial portion of their personal income to the consumption of air transportation. This is true primarily because the per seat-mile cost of operating general aviation aircraft is far higher than the prices charged by airlines.

The income elasticity of demand for general aviation-piston flights should also be high relative to airline travel, despite the fact that the income elasticity of demand for airline travel is also high. Higher income individuals are likely to make more trips by airline than lower income individuals. For example, a special tabulation of the National Transportation Survey by Verleger indicates that as income doubles, households take between 1.5 and 3 times the number of airline trips.² This relationship between income and air transportation is reinforced in the case of GA-piston operators by the fact that their aircraft are personal luxury items. GA-piston operators not only consume more air transportation services as their incomes rise, but also those services are of a fundamentally different and more exclusive type than services consumed by airline customers.

A.2.3 Empirical Evidence Regarding Airline and GA-Piston Demand Elasticity

Direct comparisons between general aviation and airline air transportation demand are difficult. While both airlines and general aviation produce air transportation, there are qualitative differences between them. Airline flights are generally longer, utilize significantly different equipment, are less expensive per seat mile, and are generally destined for relatively large population centers. General aviation-piston flights are generally relatively short, utilize relatively small equipment, are piloted by owners/operators, are destined for less populous areas, and require substantial investments both in terms of dollars and human capital to obtain and maintain capabilities.

To compare elasticities between airline customers and general aviation-piston owners and operators, ideally one would want to examine demand behavior controlling for all of these qualitative differences. Such data do not exist, and therefore an approximation is necessary.

What follows is an illustration of the differential between demand elasticities of the two groups based upon:

- o Available statistics on the costs and characteristics of general aviation-piston flights.
- o An econometric analysis of the elasticity of demand for airline transportation published by Ippolito.³

This approach compares the two types of air transportation while adjusting for as many of the qualitative differences between them as possible. An analysis of the sensitivity of the results to alternative assumptions is provided in Section A.2.4.

The illustration is developed in the following manner. First, it is assumed that both airline and general aviation operators are interested in air transportation in the same city-pair markets. Second, both airline customers and general aviation-piston owners/operators are assumed to have the same income levels, substitution elasticities, and income elasticities. Third, the differences in demand elasticities between the two groups are then calculated based upon the differences in the percent of income accounted for by air transportation. This is accomplished by assuming that airline customers exhibit demand elasticities equal to those in a study by Ippolito and that general aviation-piston operator's elasticity of demand is different from those of their airline

counterparts only because of the differences in the percentage of their household budgets accounted for by air transportation in the same markets. The results show GA-piston demand elasticities at least twice those of airline passengers. The difference would be even larger if the assumption of equal income elasticities is relaxed.

The actual steps involved in developing the illustration are as follows:

- o First, the costs and use characteristics for cross-country and local general aviation-piston trips are derived in Table A-1. The figures listed there are based upon the best information available from FAA studies on the costs and characteristics of general aviation flights. The table provides estimates of the cost per passenger-mile of both local and cross-country trips made in general aviation-piston aircraft. The table also shows the average flight distance for the two types of trips.
- o Second, using the data from Table A-1, the equivalent costs of producing air transportation in airliners are calculated. The assumption is made that the yield per revenue passenger-mile in airliners is 12.5 cents.
- o Third, the share of income spent on air travel by both general aviation owners and air carrier passengers can then be estimated assuming that both airline customers and general aviation owners have equivalent incomes and that general aviation owners never take air carrier

Table A-1

COSTS FOR GA-PISTON CROSS-COUNTRY AND LOCAL FLIGHTS

	Est. 1984 Operating Cost p/hour (1)	Est. Annual 1984 Fixed Cost (1)	Avg. Hours p/year (2)	Avg. Total Cost p/hour	Avg. Speed (3)	CROSS-COUNTRY TRIPS				LOCAL TRIPS			
						ATC p/mile	Seats Occupied (4)	Costs p/ Passenger Mile	Percent Hours Cross- Country (5)	Avg. Speed p/mile	Seats Occupied	ATC p/mile	Cost p/ Passenger Mile
SEP < 3	23.85	13,183	140	\$118	145	\$0.81	1.5	\$0.54	36%	105	1.7	\$1.12	\$0.66
SEP + 4	32.33	54,682	140	\$423	152	\$2.78	2.3	\$1.21	64%	128	2.0	\$3.30	\$1.65
TWINS	100.44	97,944	187	\$624	240	\$2.60	3.1	\$0.84	92%	168	2.3	\$3.71	\$1.61

(1) "Selected Statistics United States General Aviation", (1978)

(2) "General Aviation Activity and Avionics Survey", (1984)

(3) Average speed adjusted to miles per hour from "General Aviation Pilot and Aircraft Activity Survey", (1985)

(4) Ibid, Table 9

(5) Ibid, Table 18

flights. A comparison of the shares of incomes for the two groups assuming both purchase the same cross-country trips is shown in Table A-2. In all cases, GA-piston operator's cost of air transportation is several times that of their airline's counterparts. Shown in Table A-3 is a similar comparison assuming that airline customers purchase air transportation equivalent to both cross-country and local general aviation-piston trips. Again, the relative share of income accounted for by general aviation-piston transportation is several times that of the airline counterpart.

- o Fourth, using the modified Slutsky equation and Ippolito's airline demand elasticities, GA-piston income are substituted for airline shares in order to develop estimates of general aviation-piston demand in similar markets. The results comparing cross-country flights only are shown in Table A-4. General aviation-piston elasticities of demand are between 1.9 and 3.2 times larger than for airline customers. In Table A-5, an analysis assuming that both groups purchase air transportation equivalent to both local and cross-country general aviation flights indicates that GA users exhibit demand elasticities between 2.4 and 5.0 times larger than their airline counterparts.

In light of this illustration, the assumption that general aviation-piston owners and operators exhibit demand elasticities

Table A-2

COMPARISON OF SHARES OF INCOME

CROSS-COUNTRY AND AIRLINE FLIGHTS

	<u>Average Income of GA Owner (1)</u>	<u>Annual Cost per Passenger of GA Cross-Country Flights</u>	<u>Percent of Income</u>	<u>Equivalent Cost of Air Carrier Flights at 12.5¢ yield</u>	<u>Percent of Income</u>
Single Engine ≤ 3 Seats	\$42,430	\$3,946	9.3%	\$914	2.2%
Single Engine + 4 Seats	\$57,152	\$16,479	28.8%	\$1702	2.9%
Twins 12,500 lbs.	\$102,367	\$34,683	33.8%	\$5161	5.0%

(1) S. "General Aviation: Aircraft, Owner & Utilization Characteristics",
FAA-AVP-76-9; adjusted for inflation using the index of hourly wages.

Table A-3

COMPARISON OF SHARES OF INCOME
ACCOUNTED FOR BY ALL GA
FLIGHTS AND AIRLINE FLIGHTS

	<u>Average Income of GA Owner</u>	<u>Annual Cost of All GA Flights</u>	<u>Percent of Income</u>	<u>Equivalent Cost of Air Carrier Flights at 12.5¢ yield</u>	<u>Percent of Income</u>
Single Engine ≤ 3 Seats	\$42,430	\$10,155	23.9%	\$2090	4.9%
Single Engine + 4 Seats	\$57,152	\$27,123	47.5%	\$2508	4.4%
Twins 12,500 lbs.	\$102,367	\$37,718	36.8%	\$5475	5.3%

Table A-4

COMPARISON OF GA AND AIRLINE
DEMAND ELASTICITY
(CROSS-COUNTRY FLIGHTS ONLY)

	<u>Average Mileage per Cross-Country Trip (1)</u>	<u>Demand Elasticity for Airline Service (2)</u>	<u>Income Elasticity (3)</u>	<u>GA Demand Elasticity (Cross-Country Flights Only)</u>	<u>Ratio of GA Elasticity to Airline Elasticity</u>
Single Engine 5 3 Seats	220	-0.16	2	-0.30	1.9
Single Engine + 4 Seats	267	-0.23	2	-0.75	3.2
Twins 12,500 lbs.	379	-0.47	2	-1.05	2.2

(1) "General Aviation Pilot and Aircraft Survey", (1985) Table 9

(2) R.A. Ippolito: "Estimating Airline Demand with Quality of Service Variables".
Journal of Transportation Economics and Policy, (1/81) pp. 7-15

(3) P. Verleger: "Demand for Air Transportation", The Bell Journal of Economics and
Management Science, Vol 3 No. 2; and R.A. Ippolito (Ibid)

Table A-5

COMPARISON OF GA AND AIRLINE
DEMAND ELASTICITY
(ALL GA FLIGHTS)

	<u>Average Mileage per</u> <u>Cross-Country Trip</u>	<u>Demand Elasticity for</u> <u>Airline Service</u>	<u>Income</u> <u>Elasticity</u>	<u>GA Demand</u> <u>Elasticity</u> <u>(all flights)</u>	<u>Ratio of GA Elasticity</u> <u>to Airline Elasticity</u>
Single Engine 2 3 Seats	181	-0.11	2	-0.48	4.5
Single Engine + 4 Seats	257	-0.22	2	-1.08	5.0
Twins 12,500 lbs.	370	-0.45	2	-1.08	2.4

approximately twice those of airline customers is relatively conservative. The illustration hinges primarily on three assumptions:

- o Airline demand elasticities vary with distance between city pairs.
- o Both groups exhibit income elasticities equal to two.
- o The relative cost of operating general aviation-piston aircraft and airliner aircraft is well represented in Table A-1.

Each of these is briefly discussed below.

In the illustration, airline demand elasticities are used to estimate GA-piston elasticities which reflect the GA-piston income effect. The airline elasticities employed are those for the average GA-piston flight distance, and so are lower than the ones observed at average airline distances.

Whether or not airline demand elasticity varies with distance is primarily an empirical question. In shorter distance markets, one would expect stronger competition from automobiles which would tend to increase demand elasticities. On the other hand, the full price of travel includes both the fare and time. Since the fraction of the full price attributable to the fare rises with distance, the effect of a percentage change in fare on the full price increases with distance and hence so does the fare elasticity. Most recent empirical evidence tends to support the conclusion that the latter effect more than offsets the former.⁴ This was the primary reason for selecting the Ippolito study to develop the illustration.

Both the Ippolito and Verleger papers show income elasticities equal to approximately 2.4 when evaluated at the mean income and airline-trip consumption levels. In the illustration, an income elasticity of two was selected for both GA-piston and airline consumers. This assumption tends to narrow the differences between the demand elasticities for the two groups, and so is conservative. It is likely that the income elasticity of demand for GA-piston operators is higher than that of airline customers because the aircraft are luxury items which should be more highly correlated with income than purchased air transportation. The effect of higher income elasticities in GA-piston demand elasticities is demonstrated in the sensitivity analysis below.

Finally, it seems almost self evident that general aviation-piston aircraft are less efficient producers of seat-miles than airliners. Regardless of the source of the numbers, cost per seat-mile for general aviation-piston aircraft will be a multiple of that for airliners.

A.2.4 Sensitivity Analysis of Relative GA-Piston and Airline Demand Elasticity

Figures A-1 through A-6 report the results of sensitivity analyses on changes in the ratio of general aviation piston demand elasticities to airline demand elasticity. In the allocation model, this ratio is assumed to be two; that is, GA-piston users exhibit demand elasticities twice as high as airline passengers. The sensitivity analyses examine the impact on the ratio of:

- o airline yields ranging from 10.5 cents to 20.5 cents,
- o income elasticities ranging between one and three,
- o ratios of GA-piston income elasticity to airline income elasticities ranging from one to three.

All of the analyses assume that all other things remain equal. The results are reported for both cross-country flights and all GA-piston flights. The average results for all general aviation-piston operations are also reported in these figures.⁵

Figure A-1 reports the impacts on demand elasticity ratios due to changes in yields under the assumption that consumers buy air transportation equivalent to GA-piston cross-country flights. It is interesting to note from this figure that the GA-piston demand elasticity is twice as high as airline demand elasticity when airline yields are assumed to be 16.5 cents--a level commonly witnessed in the commuter airline market which serves flights of shorter stage lengths such as those at issue here. The same analysis is repeated for all flights in Figure A-2. (In this figure, the results for single engine piston aircraft less than three seats are virtually identical to the average.) Notice that the ratios of GA-piston demand elasticities to airline demand elasticities always exceed two when it is assumed that consumers buy air transportation equivalent to all GA-piston flights. For relevant yield levels, the average GA-piston elasticity is twice as high as that for airline elasticities.

Figure A-3 reports the results of the income elasticity sensitivity analysis for cross-country flights. Here, income elasticities vary between one and three. Even if the income

Figure A-1

YIELDS

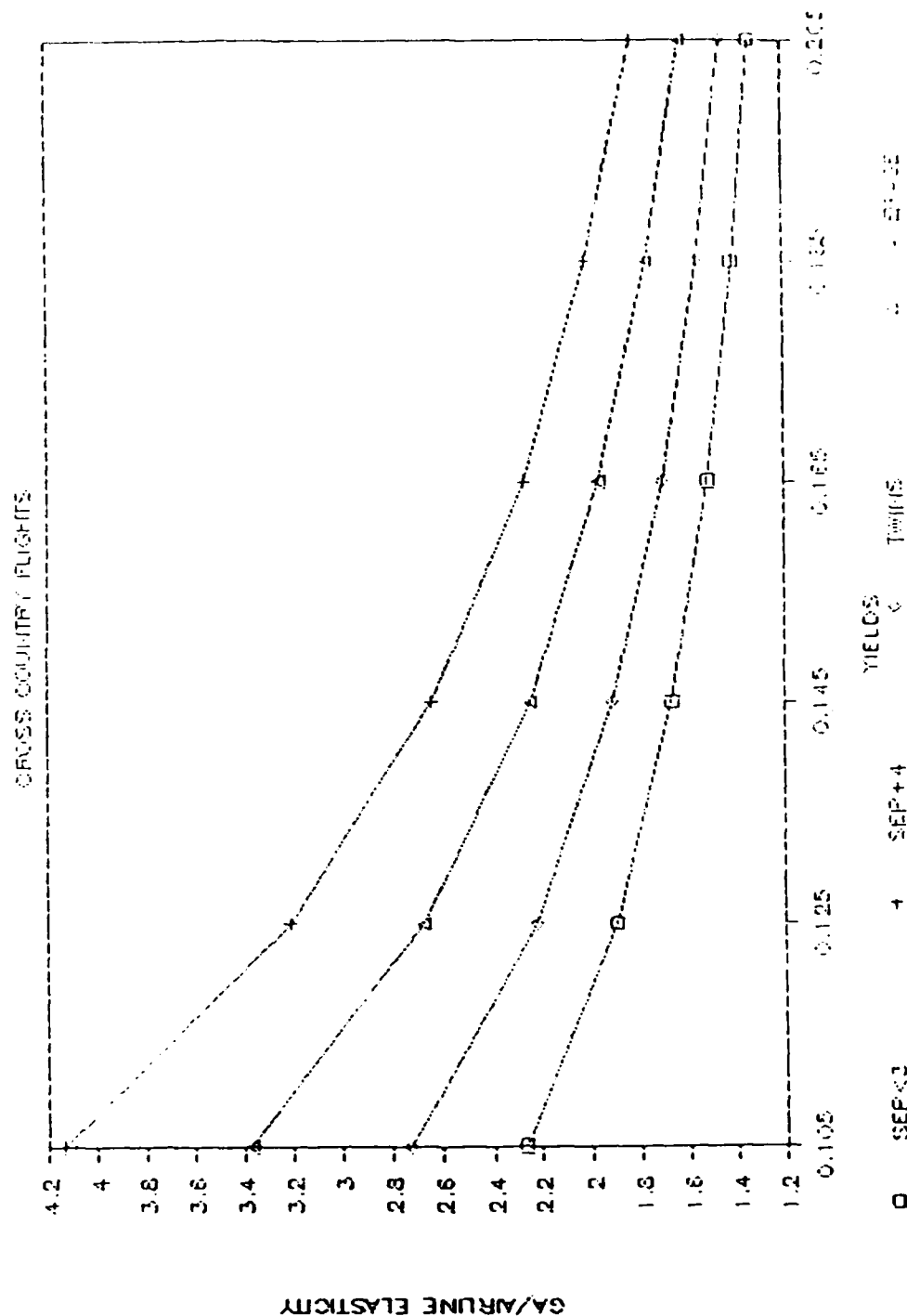


Figure A-2

YIELDS

ALL FLIGHTS

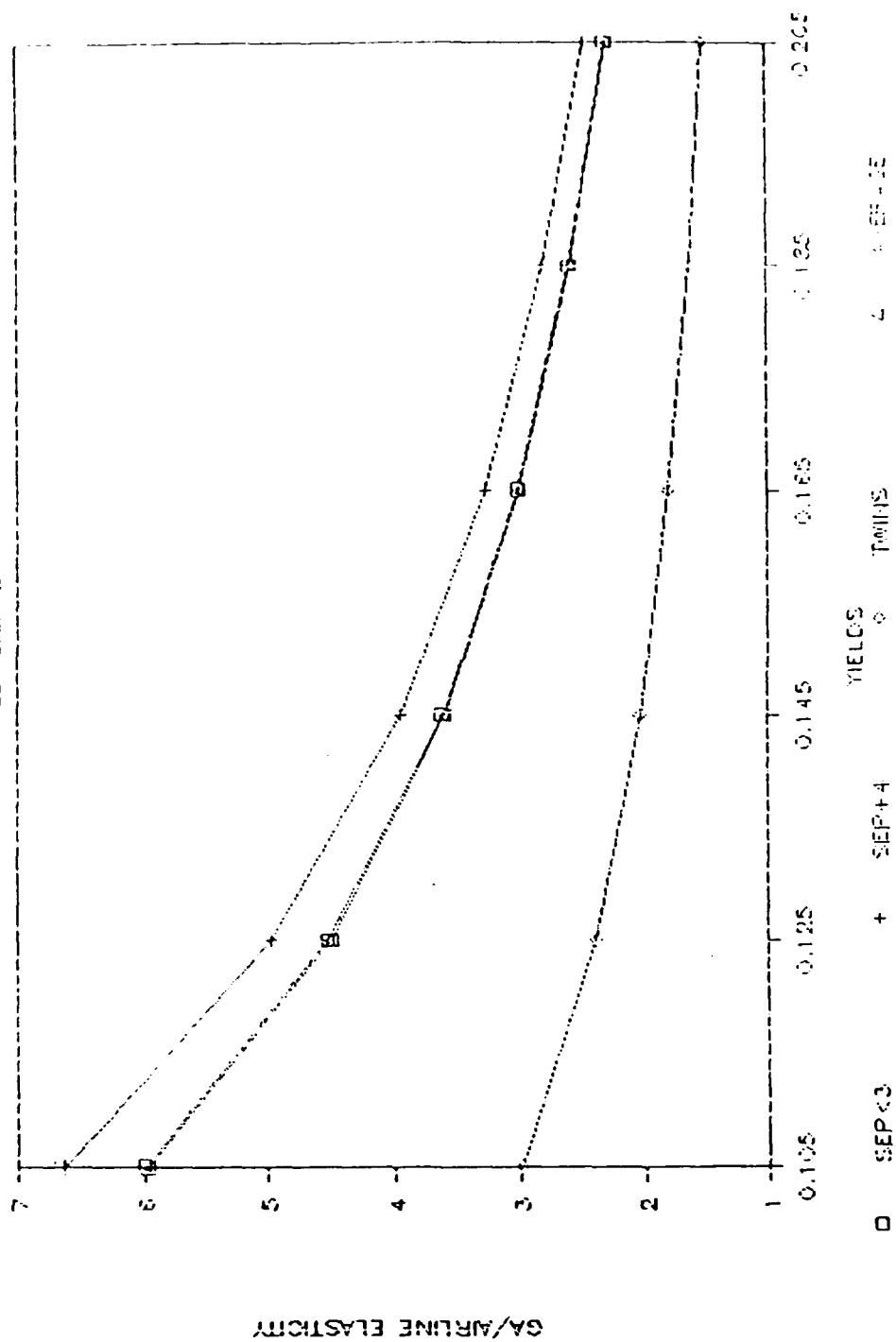
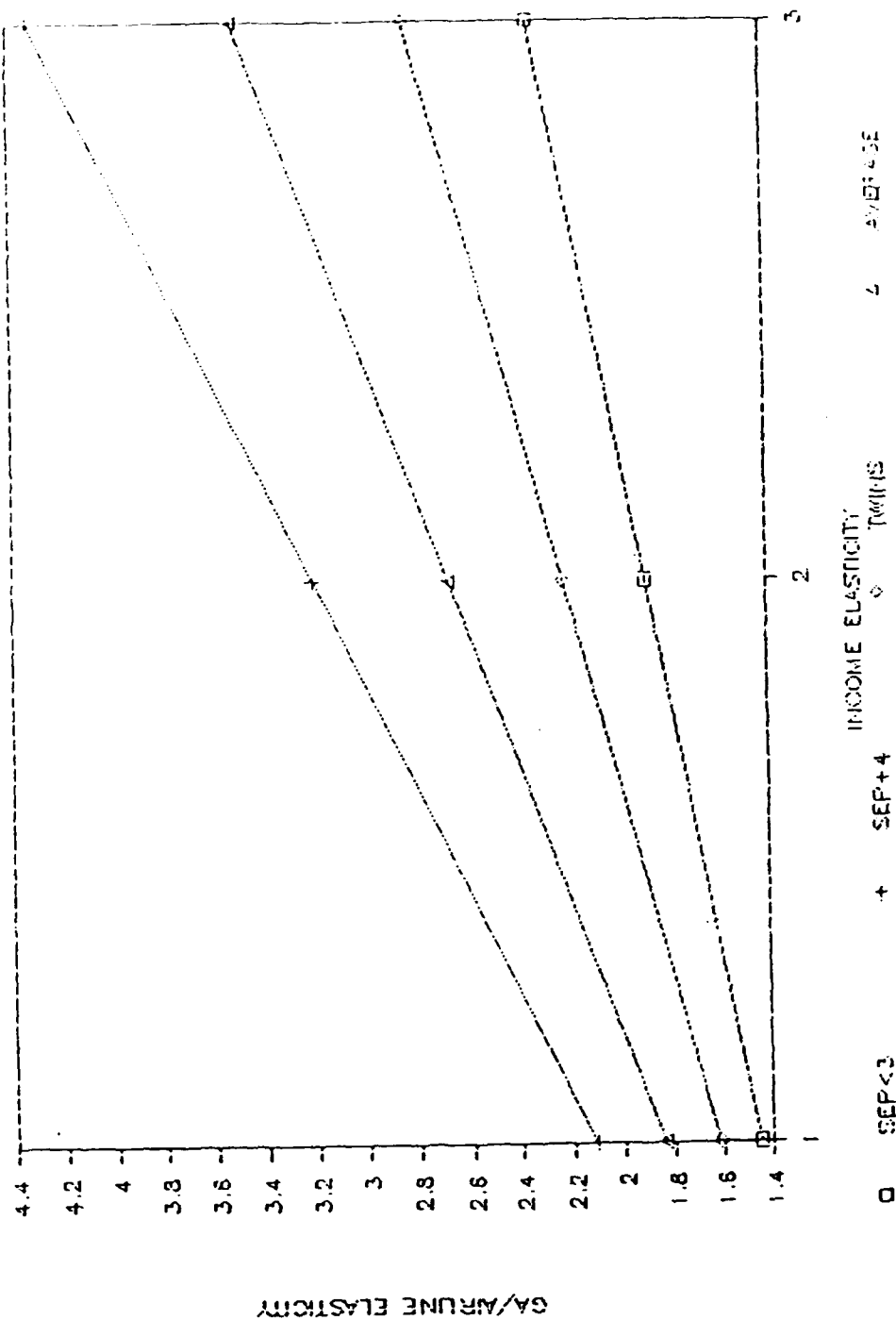


Figure A-3

INCOME ELASTICITY

GROSS COUNTRY FLIGHTS



elasticity for air transportation is one--i.e., the quantity of air transportation increases proportionately with income--the ratio of the demand elasticity for the average GA-piston operators is approximately twice as high as that of their airline counterparts. When looking at the results for all flights in Figure A-4, the lowest ratio of demand elasticities is two, for average piston aircraft is 3.5. For relevant income elasticity levels, the GA-piston operations exhibit demand elasticities at least twice those of their airline counterparts.

Reported in Figure A-5 are the results of the cross-country sensitivity analysis when general aviation income elasticities are allowed to increase above the level assumed for airline passengers. For example, if general aviation-piston income elasticities are twice as high as those reported for airline passengers, then average GA-piston operators would exhibit elasticities of demand over four times larger than their airline counterparts. The results for all general aviation flights are even more dramatic as reported in Figure A-6.

The sensitivity analysis indicates that the ratio of general aviation demand elasticity to airline demand elasticity is at least two in virtually all cases.

A.2.5 Why General Aviation-Piston Operators Should Evidence Higher Demand Elasticity Than Other General Aviation Users

In Section A.2.2, it was shown that most of the flights made for personal reasons by general aviation operators are made by the piston group. This group is more likely to depend upon personal income to defray the expense of operating their aircraft than any of the other general aviation groups. As a result, they

Figure A-4

INCOME ELASTICITY

ALL FLIGHTS

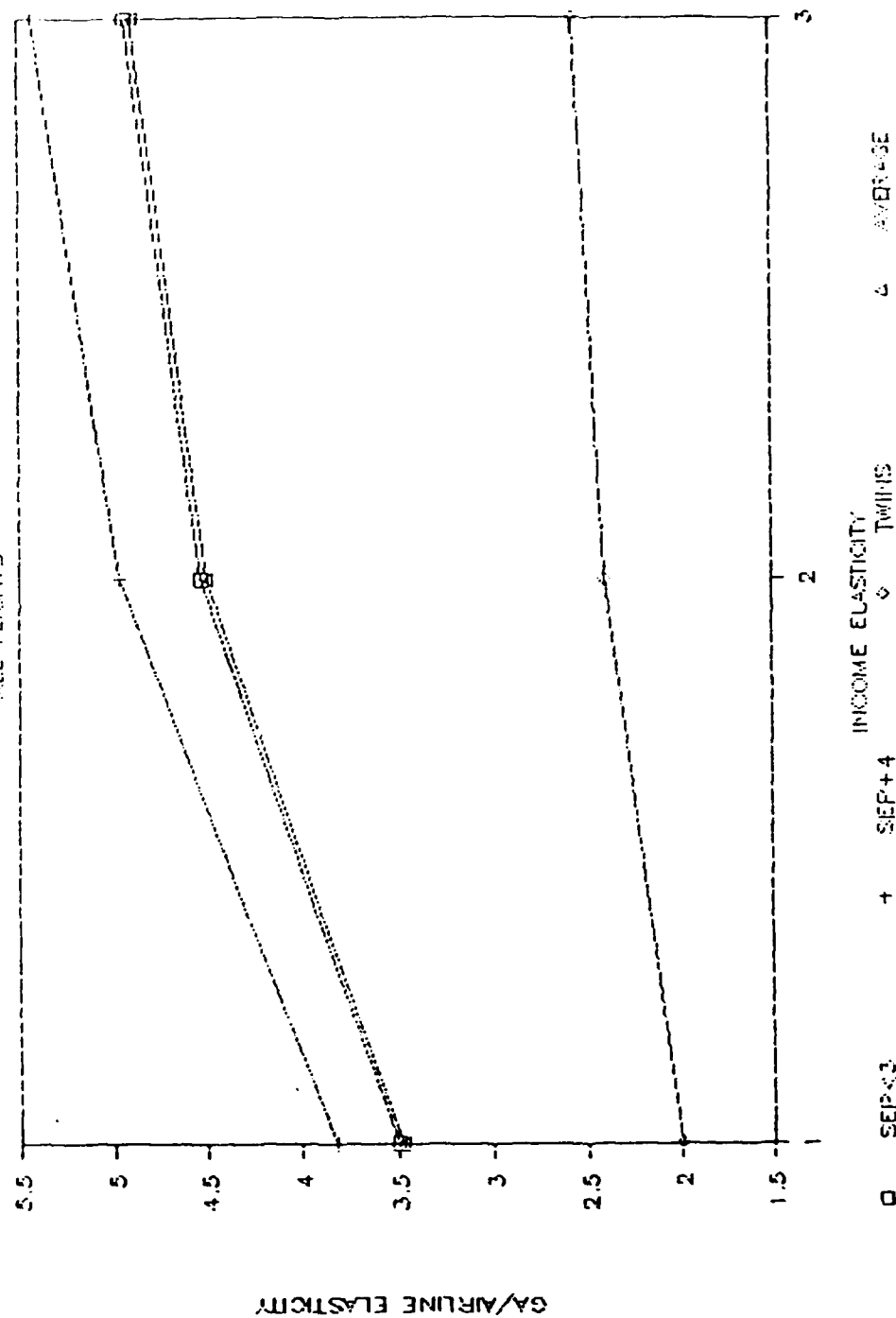


Figure A-5

INCOME ELASTICITY RATIOS

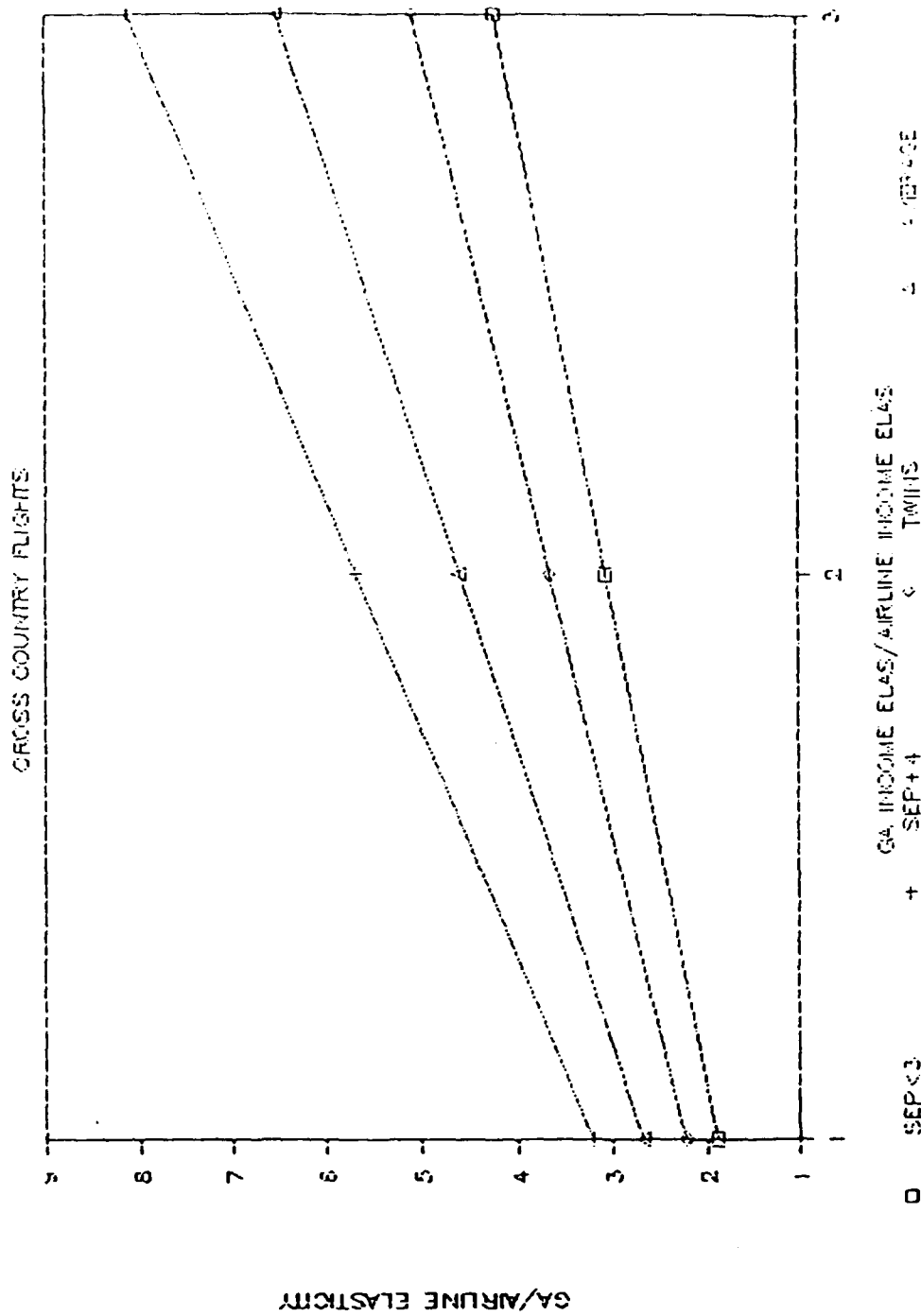
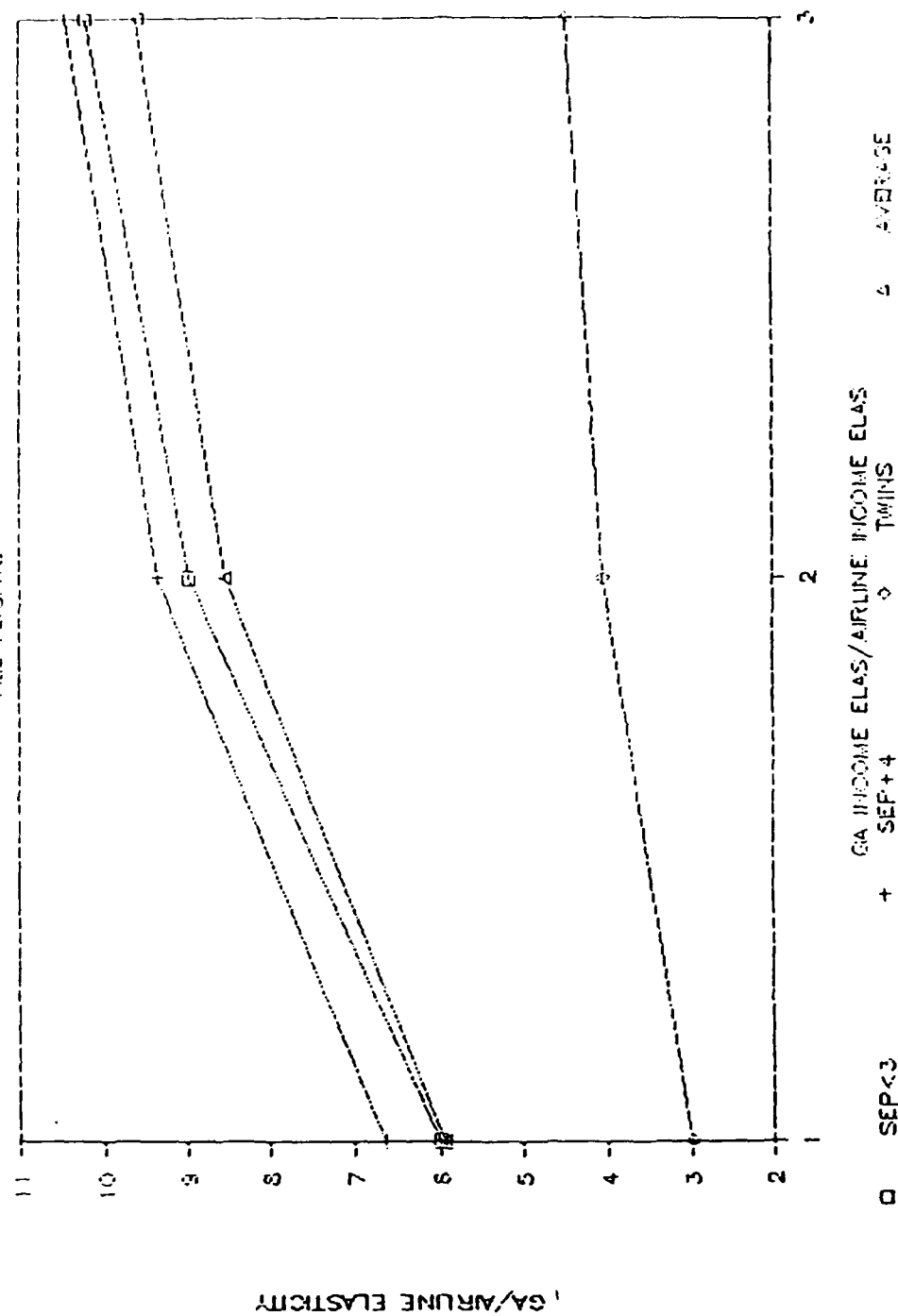


Figure A-6
INCOME ELASTICITY RATIOS
ALL FLIGHTS



will be less likely to be able to write-off aircraft operations for business reasons than their counterparts in other general aviation groups.

Furthermore, there are likely to be fewer substitutes for the services produced by other general aviation user groups than there are for general aviation-piston operators. The latter use their aircraft for consumption reasons, and there are numerous alternative luxury goods that they could purchase if the cost of general aviation rose substantially relative to airline travel. However, there may be very few substitutes for the services of air taxis, or for the output of rotorcraft, turbo-prop, and turbo-jet aircraft. As a result, the substitution elasticity should be lower for these groups than it is for GA-piston users. The pattern of sales of GA aircraft tends to confirm this. Recently, the cost of operating GA-piston aircraft has increased resulting in a dramatic downturn in sales of new GA-piston aircraft. At the same time, the cost of utilizing other GA services has also risen, but users' willingness to pay large premiums for these services and to continue to buy these aircraft tends to indicate that there are few substitutes available.

The theoretical and empirical arguments set forth in this section support the assumption that GA-piston operators have a demand elasticity at least twice as high as those of other types of general aviation users as well as airline customers. This assumption was incorporated into the allocation model used for both the full-cost and minimum general aviation system

allocations. Section A.3 provides a formal derivation of the Ramsey price formula, indicating the important role played by relative demand elasticities.

Section A.3 A Formal Treatment of Ramsey Pricing

Section A.3.1 Efficient Allocation in the Absence of Joint Costs

In the absence of joint costs, the most efficient allocation of resources occurs when prices for each service are equal to marginal costs. The net benefits from the consumption of each service can be defined as:

Net benefit of Service A:

$$\int_0^{q_a} P_a(Q_a) dQ_a - \int_0^{q_a} MC_a(Q_a) dQ_a$$

Net Benefit of Service B:

$$\int_0^{q_b} P_b(Q_b) dQ_b - \int_0^{q_b} MC_b(Q_b) dQ_b$$

Because there are no joint costs to be allocated between the two services in this case, maximum net benefits occur where the price of each service equals its marginal cost. Taking the partial derivative with respect to output yields:

Maximum Net Benefit of Service A: $P_a - MC_a = 0$, or

$$P_a = MC_a$$

Maximum Net Benefit of Service B: $P_b - MC_b = 0$, or

$$P_b = MC_b$$

This is the familiar result showing that economic efficiency is maximized when price equals marginal cost.

A.3.2 Efficient Allocation in the Presence of Joint Costs

Now suppose there are joint costs to be allocated between Service A and B. It is no longer possible to set prices at marginal costs since there are joint costs to be covered by consumers of the two services. In order to allocate the joint costs in the most economically efficient manner, it is desirable to maximize the net benefits of the two services subject to the constraint that joint costs be covered. In other words, the objective is to disturb as little as possible the market result which would exist in a perfectly competitive market while covering joint cost.

The problem can be set up as:

Maximize:

$$\begin{aligned} & \int_0^{q_a} P_a(Q_a) dQ_a - \int_0^{q_a} MC_a(Q_a) dQ_a \\ & + \int_0^{q_b} P_b(Q_b) dQ_b - \int_0^{q_b} MC_b(Q_b) dQ_b \end{aligned}$$

Subject to:

$$P_a Q_a - \int_0^{q_a} MC_a(Q_a) dQ_a + P_b Q_b - \int_0^{q_b} MC_b(Q_b) dQ_b - J = 0$$

where J represents joint costs. Forming the Lagrangian, and taking the partial derivatives with respect to output for Service A yields:

$$\begin{aligned} \frac{\partial L}{\partial Q_a} &= P_a - MC_a - \lambda \left(P_a + Q_a \frac{\partial P_a}{\partial Q_a} - MC_a \right) = 0 \\ &= P_a - MC_a - \lambda (P_a - MC_a) - \lambda \left(P_a \frac{Q_a}{P_a} \frac{\partial P_a}{\partial Q_a} \right) = 0 \\ &= (1 - \lambda) (P_a - MC_a) = \frac{\lambda P_a}{E_a} \end{aligned}$$

where E_a = elasticity of demand for Service A. Rewriting this last equation yields:
$$\frac{(P_a - MC_a)}{P_a} E_a = \frac{\lambda}{1-\lambda},$$

where $\frac{\lambda}{1-\lambda}$ is a constant. Repeating the same steps for Service B would yield the same results, so that:

$$\frac{(P_a - MC_a)}{P_a} E_a = \frac{(P_b - MC_b)}{P_b} E_b = \frac{\lambda}{1-\lambda}$$

This equation indicates that the markup for each service above marginal cost will depend on the relative elasticities of demand for the services. The higher (lower) the relative value of the demand elasticity for a service, the lower (higher) the markup above marginal costs.

A.3.3 Equalizing the Marginal Loss in Consumer Welfare Per Extra Dollar Contribution to Joint Cost

The Ramsey prescription also implies that user welfare losses due to setting taxes above marginal costs will be minimized. This occurs when the net welfare loss for an extra dollar of contribution to joint costs is equal for all users. To see this, begin with the previous result:

$$\frac{(P - MC)}{P} E = \frac{\lambda}{1-\lambda}$$

$$\frac{P - MC}{P} = \frac{\lambda}{1-\lambda} \left[\frac{1}{(\partial Q / \partial P) (P/Q)} \right]$$

$$P - MC = \frac{\lambda}{1-\lambda} Q \left[\frac{1}{(\partial Q / \partial P)} \right]$$

$$(P - MC) \frac{\partial Q}{\partial P} (1-\lambda) = \lambda Q$$

$$(P - MC) \frac{\partial Q}{\partial P} = \lambda \left[(P-MC) \left(\frac{\partial Q}{\partial P} \right) + Q \right]$$

The left-hand side of this equation represents the loss in consumer welfare ($P-MC$) due to a small decrease in output which in turn is caused by a price increase (markup above marginal cost).

The right-hand side is the net increase in contribution to joint costs for a one unit increase in price. The first term in the bracket is the loss in net revenue due to the unit rate increase. This loss is offset by the second term (Q) which is the number of units of output supplied, each of which will earn an extra unit of revenue. The sum of everything in the brackets is the increase in net revenue due to a one-unit price increase.

The whole equation says that the net loss in benefits for a dollar price increase should be proportional to the net revenue income per dollar price increase. Since this will be true for all services, the net loss in benefits for an extra dollar of profit should be the same for all services:

$$\frac{(\text{loss in welfare})}{(\text{gain in net revenue})} = \lambda \quad \text{for all } i.$$

NOTES

¹"General Aviation Activity and Avionics Survey," (1984).

²p. Verleger: "Demand for Air Transportation;" The Bell Journal of Economic and Management Science, Vol. 3, No. 2 (Autumn 1972) p. 452.

³R.A. Ippolito: "Estimating Airline Demand with Quality of Service Variables," Journal of Transportation Economics and Policy, (January 1981), pps. 7-15.

⁴For a good literature review, see: S. Morrison and C. Winston, "An Econometric Analysis of the Demand for Intercity Passenger Transportation," in Research in Transportation Economics, Volume 2 (1985), pps. 213-238.

⁵The average elasticity was derived by weighting the results for the three aircraft types by the total number of each currently active in the fleet as reported in "General Aviation Activity and Avionics Survey" (1984).

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